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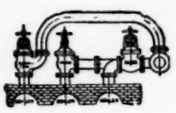

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POWER

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Fred R. Low
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Volume 67 New York, February 7, 1928 *Number 6*

The Power of Publicity

IN THE old days men came to be rulers by sheer superiority. The group was in trouble and a leader arose and showed them the way out. Or they coveted the possessions of another group and a master brigand arose and showed them how to get them.

He became the King, the König, the Knowing One, and he and his supporters the established rulers.

It was the natural system, the system by which the best qualified stag becomes the leader of the herd, the system by which the will and ability to do asserts itself when something needs to be done.

But such leadership, established and become hereditary, was not always continuingly wise and unselfish.

Things got so bad, at times, that the people objected to being exploited and demanded a voice in the making of the laws, the levying of taxes, the determination of policies and the running of the government.

They got the franchise, and it has worked fairly well. It has made possible an orderly opposition on the part of the masses to oppression and an orderly demonstration of their power in directions that the majority considered for the collective good.

It is a safeguard against the older, cruder forms of despotism, but is it demonstrably the best way to run a country?

The mass has too much inertia to get into action quickly in an emergency.

The average unit of the mass has little interest in public questions unless he thinks that they threaten his material interest or violate his hereditary prejudices, convictions and habits of thought.

He is an uncrowned king, but he does not work at it.

He gets his opinions from the printed page and lately, and increasingly, from the broadcast word.

The real rulers of the future democracy will be those who control these avenues of access to the popular mind and these processes of cultivating the public thought.

If fearless, independent journalism is to give place to syndicated propaganda, if high-minded publicism and statesmanship is to relinquish the editorial chair to servants of party and class interests, the rule will pass from the people and their chosen representatives to those who tell them whom to choose.

F. R. Low

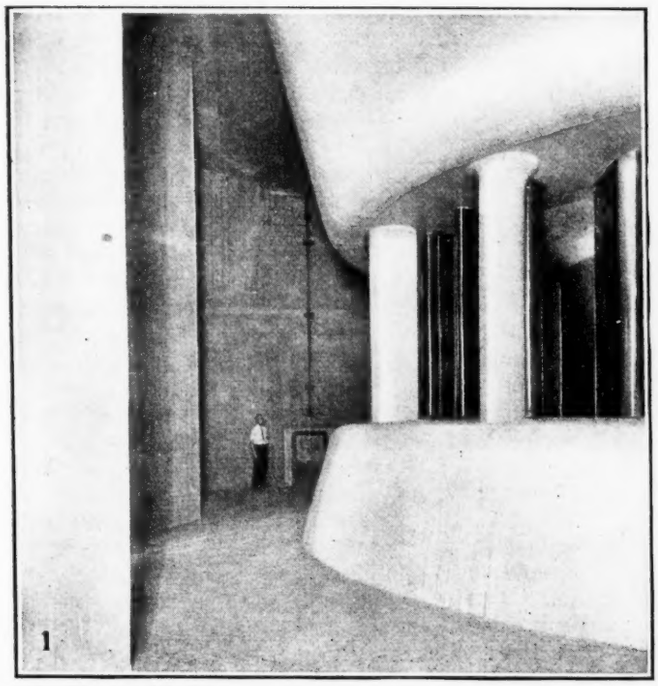
View of Federal dam from Indiana end; power house in distance

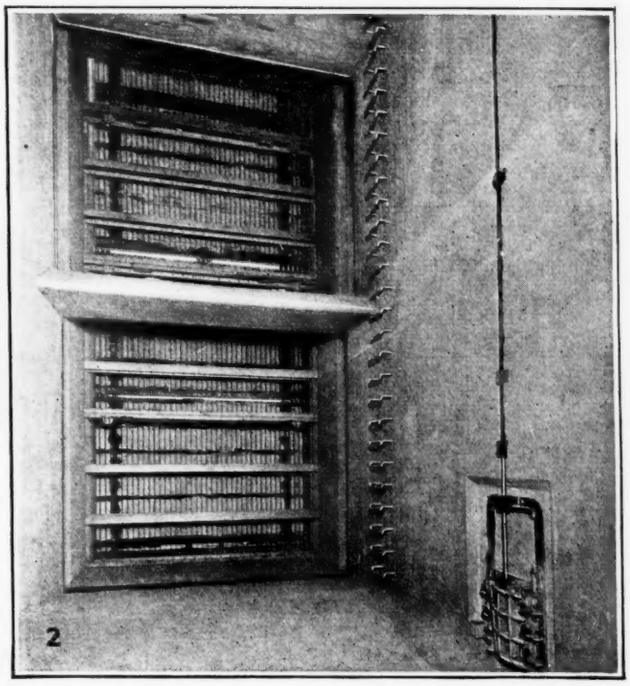
Low-Head Plant at the

Falls of the Ohio To Produce 100,000 Kw.

ON NOVEMBER 1 of last year six of the eight 13,500-hp. hydro units of the initial installation at the Falls of the Ohio, opposite Louisville, Ky., were placed in operation. The other units will be ready soon, and with provision for the two-unit addition to the plant at some future date, there will be available in hydro power an aggregate of 135,000 hp., or in generating capacity 100,000 kw. The present capacity of the steam plant at Louisville is 92,000 kw., and when needed, additional steam capacity reaching ultimately 185,000 kw. will be installed in a station to be erected in proximity to the hydro plant. This Byllesby development, which has been made by the Louisville Hydro-Electric Company, a subsidiary of the Louisville Gas & Electric Company, came under serious consideration in 1922. Previous to that time unfavorable conditions existing in a stream with wide extremes in flow and a variation in stage that has been as much as 65 ft., had discouraged development. Throughout its entire length the slope of the river is flat, averaging considerably less than a foot per mile from Pittsburgh to Cairo. The only point on the river where there is a concentrated fall of any moment is at Louisville, where in three miles there is a total drop of 25¼ ft. According to the records of the last 46 years the extremes of flow at Louisville are 5,000 and 792,000

UNDER heads of 37 to 10 ft. this plant was designed to utilize the widely varying flow of the Ohio River at Louisville, Ky. Turbines of propeller type and generator stators of welded steel plate construction have effected a reduction in the size and weight of units and in power-plant cost. Economy is maintained by operating generators star-connected above three-quarter load and delta connected for loads below this rating.





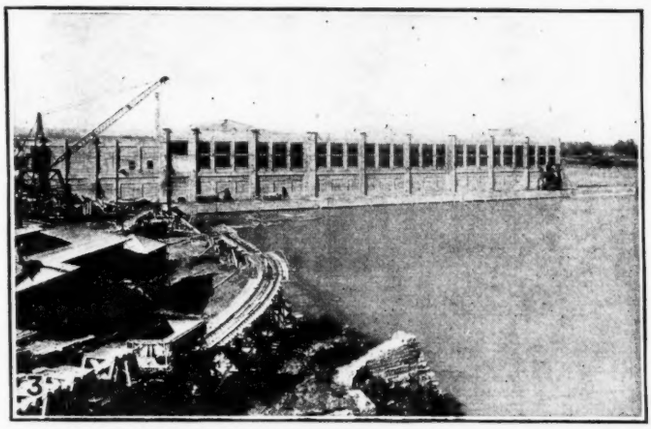


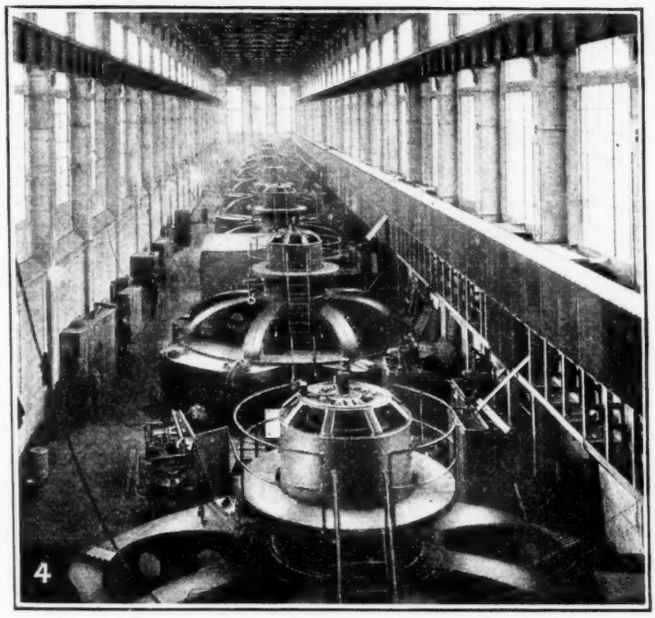
Fig. 1—Upstream face of unit No. 4, showing speed ring and guide vanes

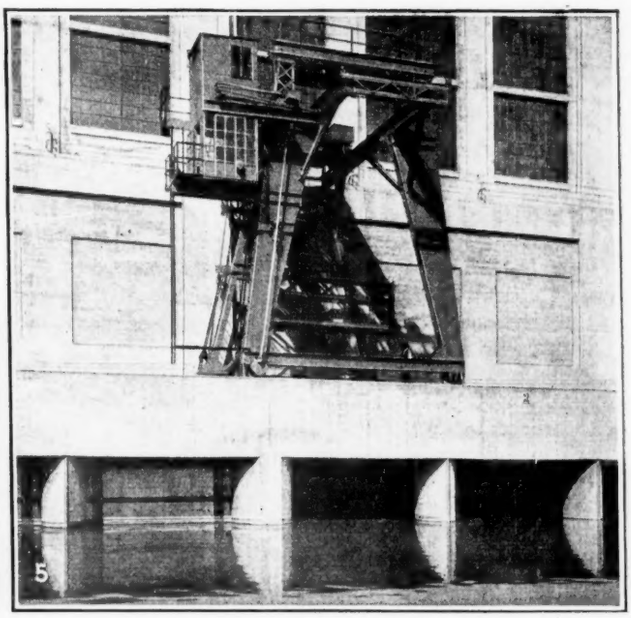
Fig. 2—Trash rack with stop logs in place and at right waterwheel scroll-case drain

Fig. 3—Upstream side of power house, which, when completed, will have a capacity of 135,000 hp. in ten units, eight now being installed

Fig. 4—Interior of power house with six of the eight 12,500-kva. generators in the initial installation ready for operation

Fig. 5—Gantry crane which serves headworks





sec.-ft. The average flow is 117,600 sec.-ft., but it is not practicable to use more than 32,000 for the development of power. On this basis there will be an average of only twenty days a year when the plant can operate at approximately full capacity. At other times the possible power output will be reduced either by the available water being below the plant's requirements of 32,000

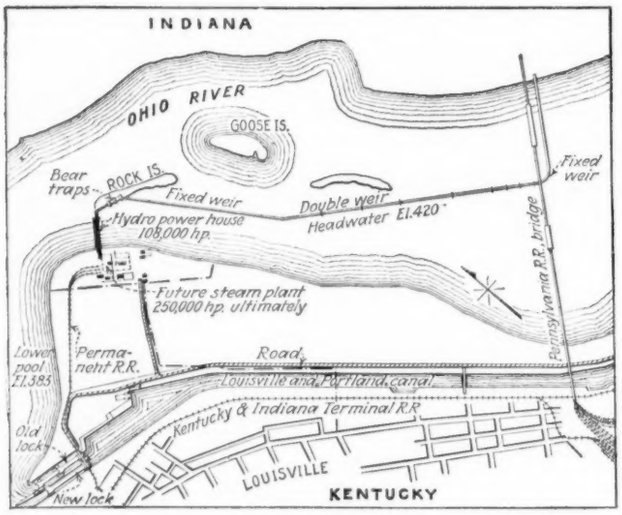


Fig. 6—General arrangement of the development

sec.-ft. or by decrease of the head caused by the backwater during periods of ample flow.

At low stages of the river an operating head of about 37 ft. will be obtained. As the flow increases, the tailwater rises while the controlled upper pool remains stationary, with a resulting decrease in the head on the plant. When the flow becomes about 350,000 sec.-ft. the head will be reduced to 2.5 ft. At this flow the discharge capacity of all the water passages in the dam will have been reached, and at greater discharges both headwater and tailwater will rise, their difference in levels decreasing until at the maximum flow of about 750,000 sec.-ft. the head will be entirely obliterated.

Normally, the reduction in head from floods occurs during the early months of the year. In an average year there will be forty days when the head will be less than ten feet and no power can be generated.

Conditions Affecting Power Development

The conditions affecting power development were: A low head, floods which for forty days in the year reduce this head so that no power can be generated, low water at certain periods and at other times low head so that the plant may operate at full capacity only twenty days in the year, an extreme high-water stage and navigation structures to be co-ordinated with the power plan.

Preliminary studies by the engineers of the Byllesby Engineering & Management Corporation, taking into account these unfavorable conditions, indicated that this hydro installation would offer no substantial immediate economies over a modern steam plant, but when an estimated annual output of 400,000,000 kw.-hr. could be utilized, the plant would be justified as a means of conserving natural resources and as an investment. An enabling factor was the comparatively low cost per kilowatt of installed capacity. Including all equipment, a transmission line to the Waterside steam station of the Louisville Gas & Electric Company, and the substation at that plant, the total figure is placed at $7,877,000. On the basis of the present eight-unit plant rated to develop 108,000 hp., or 80,000 kw., the unit cost reduces to $72.94 per horsepower, or $98.46 per kilowatt.

Reference to the headpiece and Fig. 6 will show the general location of the ell-shaped government navigation dam, 8,650 ft. long, and the power house. Starting on the north, or Indiana, shore, the base of the ell extends to midstream, where a turn is made and the leg extends downstream to a point near the base of the island formed by the main current of the river and the Louisville & Portland Canal. At this end is the power plant, bear-trap gates and a sluiceway. This location of the dam was selected on account of the advantageous conformation of the river bed and the good foundations, and because the ell shape allowed for the requisite length of movable dam to pass the floods.

Power House Building

The power-house building containing the first eight units is 534 ft. long and 74 ft. wide from the upstream line of the headwork to the downstream wall of the superstructure. Center-to-center spacing of units is 58 ft., but between units 2 and 3 and between units 5

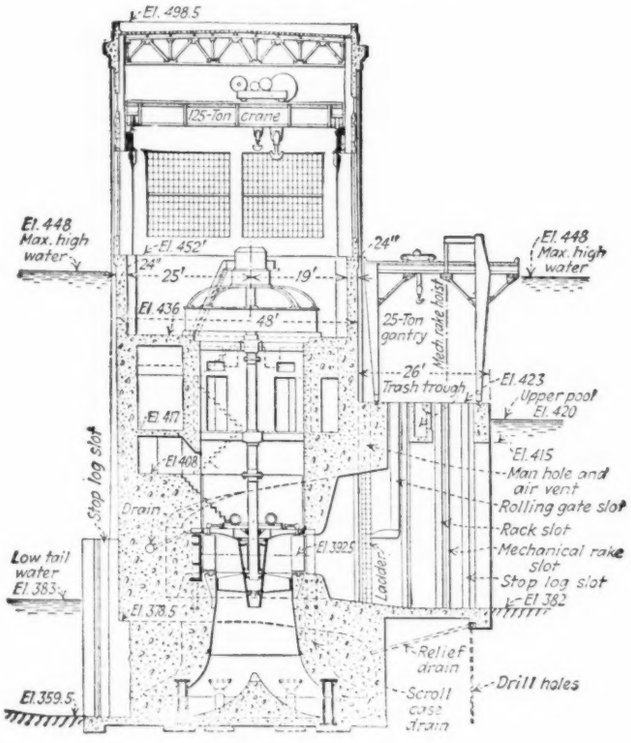


Fig. 7—Power house designed for 69-ft. rise in tailwater and 32-ft. rise in headwater

and 6, where expansion joints are carried through the structure, the spacing is increased to 64 feet.

Being placed at an elevation of 436 ft., the generator-room floor is twelve feet below possible high water, so that a wall two feet thick, carried entirely around the generator room, is reinforced to take water pressure. As the upward pressure at maximum flood exerted on the

scroll-case roof and the turbine cover plate of a unit approximates 7,500,000 lb., the weight of the structure above the scroll-case roof was designed to exceed this uplift.

Three feet above the normal upper pool level is the headworks platform. One set of headgates for the entire plant is provided. The three lower leaves are of ordinary I-beam and steel-plate construction, but the upper leaves, which seat on a horizontal concrete beam, are designed to roll down or up under pressure and seal is secured by rubber stanching strips. The removal of the upper roller sections equalizes the water pressure, so that rollers on the lower leaves would be of no advantage.

Mechanical Trash Rack Rakes Used

Reference to the sectional elevation, Fig. 7, will show the slots provided for these gates, the trash racks and mechanical rake in front of them and for the stop logs at the inlet from the upper pool. The trash racks, which are built in removable sections, are about 37 ft. high, the bars being welded to an angle frame, bolted to a supporting structure. Immediately in front of the racks is a Newport News Shipbuilding Company mechanical rake, which is used to keep the rack bars clean. The débris from the racks is deposited in a trough running the full length of the power house. The trough is kept flushed by running water which discharges into the tailrace at the outstream end of the power house. In handling the trash situation resulting from the removal of the upstream cofferdam, the operation of the rake proved its value. Timbers 12x14 in. in section and 14 ft. long and heavy oak railway cross-ties were successfully handled. To rake a complete rack section 37 ft. deep by 14 ft. wide takes but seven minutes.

One full set of stop logs consisting of steel frame gates filled solid with concrete for rigidity and to give the necessary weight for closure, has been provided. Weighing fifteen tons, the submerged stop-log sections presented an interesting handling problem which was met by the design of a special steel carrying device provided with hooks that automatically fit into pockets in the logs when it is desired to raise them and automatically release the logs after they have been lowered into position. These stop logs, as well as the head gates and trash racks, are handled by a twenty-ton gantry crane. To keep the electrical equipment above maximum high water, it is carried at an elevation 30 ft. above the runway rails.

Owing to severe trash conditions common to floods in the Ohio River, during which driftwood collects in great quantities and tree trunks 50 ft. long are not uncommon, the precaution was taken of stretching a diagonal boom across the pool at an angle of about 45 deg. with the direction of flow. This boom was built of heavy squared timbers, bolted together in sections and anchored in place by heavy steel cables attached to anchors set in the rock bottom previous to raising the water in the forebay. The bottom of the boom is about four feet below the water and on the top 12 inches above water is a plank walkway from which an operator may push and help along the débris that may have collected against it. At the lower end the boom terminates at two bear-trap gates in the Federal dam, each 100 ft. wide, which being hydraulically operated may be easily depressed and thus allow the current to sluice the débris over them to the downstream side of the dam.

Another function of the boom is the deflection of floating ice during the winter toward the bear traps. To stop the ice that may reach the plant, a concrete curtain wall running across the headworks in front of the trash racks has been provided. With the bottom of the curtain wall five feet below and the top three feet above the normal pool level, floating trash or ice will be prevented from reaching the trash racks, and will be floated longitudinally along the power house and passed through a trash sluiceway, eight feet wide and equipped with a gate of the bear-trap type at the outstream end of the building.

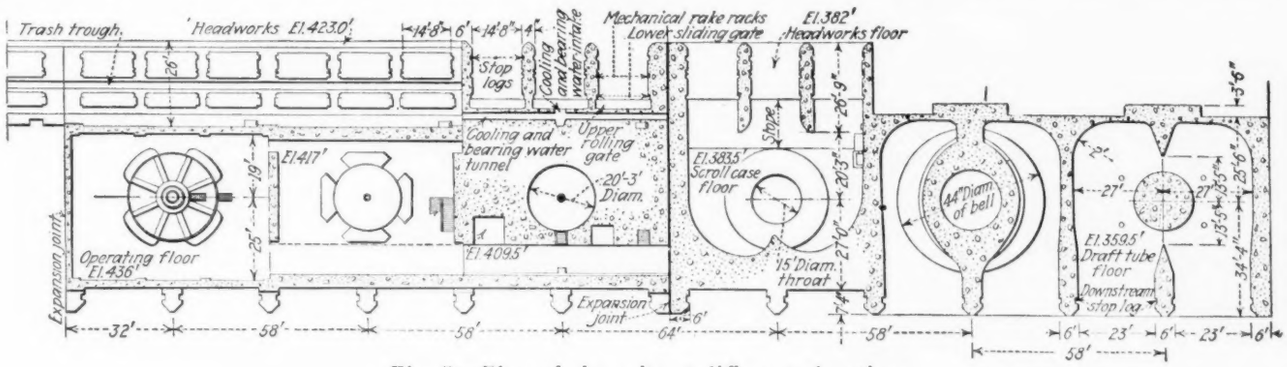


Fig. 8—Plan of six units at different elevations

The control valves for all bear-trap gates are placed below the deck of the concrete headworks and covered by steel plates, so that they are entirely under cover and cannot be fouled by débris during flood conditions. As the upper leaf of the bear-trap folds down over the rear gate to a horizontal position in closing and as the raising of the gate is accomplished by admission of water to the space between the leaves, there is no opportunity for entanglement of the débris. For the foregoing reasons this type of gate is regarded with favor on the Ohio.

Selection of the Waterwheels

Selection of turbines of the propeller type has been advantageous, as the speed can be maintained through a variation in head from 37 ft. down to about 10 ft. and with the relatively high speed of 100 r.p.m., it has not only been possible to keep down the cost of electrical equipment within economical limits, but with generators of relatively small diameter it has been possible also to reduce the size and therefore the cost of the power house.

The center lines of these runners, which are fifteen feet in diameter, are only 3½ ft. above low tailwater, so

that for a large part of the year they will operate submerged. The shafts are 23 in. in diameter and from the bottom of the runner hubs to the thrust bearing above the generator are 67 ft. long. In addition to the thrust bearing each unit has four steady bearings, located at the top and bottom of the generator, immediately above the runner and at an intermediate point between the turbine and the generator.

At 37-ft. head, each unit will pass about 4,000 cu.ft.-sec. at full gate, making a total flow through the power plant when fully loaded of 32,000 cu.ft.-sec. Guarantees of power output, made by the manufacturers, Allis-Chalmers Manufacturing Company, for operation under reduced head are as follows:

Head, Ft.	Rate, Hp.
37	13,500
32	11,250
27	8,900
22	6,690
17	4,500
12	2,600

At low flows it will be possible to operate part of the units at best efficiency, guaranteed to be 87 per cent. At reduced head the river flow, of course, will be greater than plant capacity, so that efficiencies at part gate are not important.

Generator Frames Welded

Each turbine drives a General Electric Company 12,500-kva. 14,000-volt three-phase 60-cycle generator, provided with a direct-coupled exciter on top of the generator shaft. Making the generator stator frames of welded steel-plate construction effected a considerable saving in size and weight, with a consequent reduction in power house cost. They are totally inclosed and have a closed system of ventilation, in which the air is circulated continuously through the machines and tubular coolers, through which a continuous supply of water is pumped from the headrace by induction-motor-driven centrifugal pumps.

An interesting fact is that the motor driving the cooling-water pump for each unit is connected through transformers directly to the generator leads, so that the motor picks up and shuts down with the starting and stopping of the main unit. The reasons for this type of generator ventilation were the high temperatures prevailing at Louisville during the summer months and the dust and ashes that may result from the operation of the future steam station to be built beside the hydro plant. It was the belief that the additional cost of the cooling system would be more than offset by the saving in the cost of generation owing to the positive and continuous results to be expected with a supply of cool, clean air passing through the generators.

Connection of Generator Windings

Another interesting feature of the generator, brought about by the varying conditions of head and the importance of converting all the horsepower developed by the wheels into electrical energy, is the provision whereby at three-quarter load and above, the generators will be connected star. When operating below three-quarter load, by means of suitable double-throw disconnecting switches, the generator connections can be changed to delta. This change in connections results in an increase in generator efficiency and provides an additional output of about 1,000,000 kw.-hr. per year, which would be lost were the generators to operate at all times with their windings connected in star.

Owing to the size of the development and the operating conditions due to seasonal changes in stream flow, the switching arrangement has been made as simple as possible. Power generated at 14,000 volts is collected on double buses of the box type arranged in steel enclosures along the upstream wall of the power house. The double bus permits easy and safe inspection, and at the same time facilitates the segregation of machines in accordance with load and river conditions and the requirements of system operation. Each generator has its individual control panel adjacent to the machine, which contains all the instruments and relays for automatic operation. These panels are inclosed in steel cubicles, with wire-glass doors at the front of the inclosure, to protect the instruments against injury or moisture.

The units are started manually by a floor attendant upon receipt of a signal from the supervisory control cabinet, and upon reaching normal speed they are automatically synchronized and connected to the busbars.

Automatic-Control Equipment

Full automatic control equipment has been provided with supervisory control from a point near the center of the hydro plant. Upon the completion of the steam plant previously referred to, it is proposed to combine the switching and bus facilities for both stations in a building to be erected between them. The present arrangement provides for full automatic starting of the units by push-button control either remote from or adjacent to the unit. All the functions of starting up and shutting down may be cared for automatically, and the proper sequence is assurred by the use of suitable interlocking relays. Relays are also provided to care for emergencies that may arise, such as overvoltage, overload or overspeed, overheating of either generator coils or bearings, loss of the generator field or shutdown of the unit in case of the loss of the direct-current supply to the operating control bus.

The steel cubicles, housing the control equipment and the small compact control and indicating cabinet, are radical departures from the older methods of hydro-electric station layout. The new arrangement permits one man to have supervision of the entire station, all within arm's length, and gives unit control for each machine and equipment, housed separately in a dust-tight compartment. All control is readily accessible and is easy to maintain, repair and replace; and each cubicle may be disconnected and moved and a new one substituted if major repair work or replacement is required.

From the station the electrical energy will be stepped up through Westinghouse transformers from 14,000 to 66,000 volts for transmission to local distribution centers in Louisville, and it is anticipated that an outlet for the remainder of the power generated by the hydro plant will be through 132,000-volt transmission lines radiating from the station.

Design of the project was under the immediate direction of H. G. Roby, hydraulic engineer, and R. M. Stanley, electrical engineer, and under the supervision of J. W. Link, chief hydraulic engineer, and H. W. Fuller, vice-president in charge of engineering and construction, all of the Byllesby Engineering & Management Corporation, with headquarters in Chicago. A. G. Butler was general superintendent of construction.

Field Balancing Rotors at Operating Speed

By G. B. KARELITZ *Research Department, Westinghouse Electric & Manufacturing Company*

This is the first of a series of two articles that describe a method for determining the location and size of weights necessary for balancing rotors at their operating speed. Forces acting to cause vibration are analyzed in this installment.

THE modern tendency to increase the weight and size of rotating parts in high-speed power units, together with the endeavor of designers to make housings, stators and foundations as light as possible, makes vibration problems of supreme importance. Though excessive vibration may be caused by errors in construction or by faulty assembly, nevertheless in the majority of cases it can be traced to rotor unbalance.

With larger units, because of elastic distortion under high stresses, static and dynamic balancing of the rotors at low speed in special machines is insufficient and, in addition, they have to be "hand-balanced" at their operating speed. Moreover, machines once made to run satisfactorily, owing to various causes, occasionally go out of balance in service, and the correction has to be made with the least possible interference with the operation of the unit in question.

These articles do not discuss the question of vibration or balancing in general, but describe a method to determine mechanically the correction weights when balancing a rotor in its own bearings at running speed. The application of this method, both in shop practice and under service conditions during the last two years, has proved it to be practical and of an accuracy well within the present commercial requirements. The practical development work was carried out at the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company.

UNBALANCED FORCES IN A ROTOR

A perfectly machined, rigid cylindrical rotor whose geometrical axis through its journals is an axis of symmetry of the rotor, made of a perfectly uniform material, will run smoothly in its bearings provided the alignment of the machine parts is correct. The centrifugal forces acting on the rotor will be in equilibrium, and the bearings carrying the journal will be subjected only to the weight of the rotor, which is constant in size and direction. No vibration of bearing pedestals and of the whole structure will therefore occur.

On the other hand, there may be imperfections in the rotor such as shown in exaggerated form in Fig. 1. The center of gravity C may not coincide with the geometrical axis OO through the journals, and rotation will produce an unbalanced centrifugal force S. The value of this force will be such, as if the whole weight of the rotor were concentrated at the point C, which runs in a circular path of radius KC. This force S may be expressed as $S = \frac{W}{g} \times KC \times \omega^2$, where W is the weight of the rotor, g the acceleration of gravity, KC the eccentricity of the center of gravity, ω the angular velocity of the rotor. The force S rotates together with the body MN and produces rotating forces on the bearings. The force S can be considered equivalent to two forces S_1 and S_2 parallel to S, applied to the rotor at points O_1 and O_2 in the planes of the end faces I and II, on which the balancing holes are tapped as shown; then $S_1 + S_2 = S$ and $S_1 \div S_2 = KO_2 \div KO_1$.

The axis of symmetry of the rotor body MN shown in Fig. 1 is at an angle to the geometrical axis OO of the journals. Assume that this error does not affect the position of the center of gravity of the rotor, still it will cause rotational unbalanced forces. The excess of

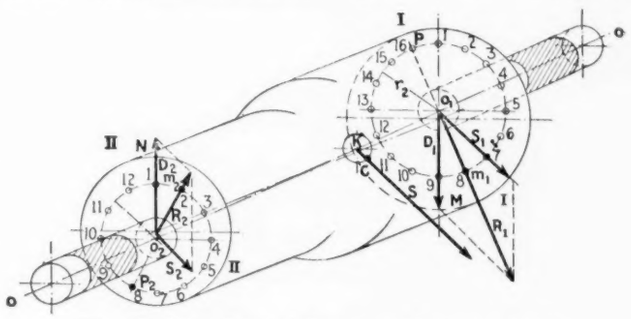


Fig. 1—Unbalanced forces acting on a rotor

material on the side M at end I and on the opposite side N at the end II will result in a force couple, the plane of which will rotate together with the rotor. The magnitude of this couple depends on the distribution of material in the rotor and is proportional to the square of the angular velocity. It may be represented by forces D_1, D_2, equal to each other, applied to the rotor at O_1 and O_2 and acting in opposite directions.[1]

The forces S_1 and S_2 are caused by the so-called static unbalance of the rotor, while the forces D_1 and D_2 are the result of dynamic unbalance. The effect of the complete unbalance can always be represented by two equivalent unbalance forces, R_1 and R_2, which are the resultants of S_1 D_1 and of S_2 D_2, respectively. R_1 and R_2 may be called the equivalent unbalance forces in the planes of the balancing rings I and II.

[1]It should be noted that non-uniform material can cause, in a geometrically perfect rotor, rotational forces analogous to the ones described for the rotor of Fig. 1.

Naturally, if the value and direction of R_1 and R_2 could, by some means, be known for a rough running rotor, and if proper correction weights P_1 and P_2 were put into the balancing holes, in order to produce centrifugal forces equal and opposite to R_1 and R_2, the rotor would become balanced and would run smoothly. It should be noted that the shape of the rotor is supposed not to be distorted by these additional centrifugal forces; this is in general true for the present type of large power machinery.

Considering the magnitude of the forces produced by the correction weights P_1 and P_2, it should be noted that, in general, the value of the centrifugal force acting on a certain mass may be found by the formula, $Q = 1.775 \times r \times W' \times \left(\frac{n}{1{,}000}\right)^2$, where Q is the centrifugal force in pounds, r the distance of the mass from the axis of rotation in inches, W' the weight of the rotating mass in ounces, n the speed in r.p.m.

For example, if the center of gravity C of a 100,000-lb. rotor running at 1,800 r.p.m. is only 0.001 in. off the geometrical axis OO, the unbalanced force will be $1.775 \times 0.001 \times 16 \times 100{,}000 \times 1.80^2 = 9{,}200$ lb., or 4.6 tons. A correction weight of 32 oz. inserted in the hole of a balancing ring of 20-in. radius will produce at 1,800 r.p.m. an unbalanced force of $1.775 \times 20 \times 32 \times 1.80^2 = 3{,}700$ pounds.

It will therefore be seen that the unbalanced forces R_1 and R_2 are proportional to the square of the r.p.m. of a rotor. At a given speed these forces are determined by the products $P_1 \times r_1$ and $P_2 \times r_2$ (see Fig. 1); that

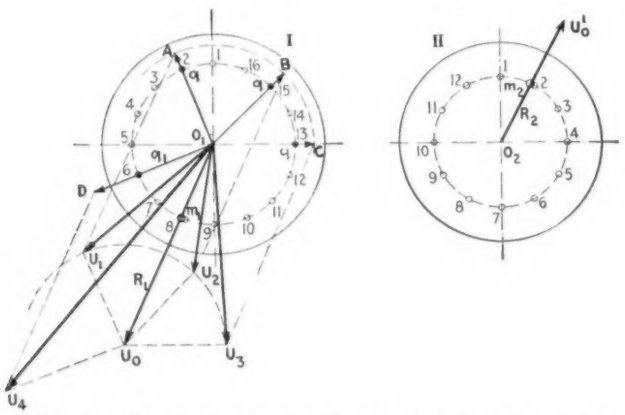


Fig. 2—Effect of trial weights on unbalance vectors

is, the necessary correction weights times the radii of the respective balancing rings. These products give the "unbalance" of the rotor at the planes O_1 and O_2, which is measured in inch-ounces or ounces at a given radius.

Vectors of Unbalance

The unbalance of the rotor is equivalent to two imaginary weights m_1 and m_2 placed on the balancing rings I and II. The unbalance can be represented by two vectors U_o and U_o', Fig. 2, directed through the position of the equivalent weights m_1 and m_2 and of length equal to m_1 and m_2 to a certain scale. The problem of balancing a rotor consists in finding the values and locations of the equivalent weights in order that correction weights $P_1 = m_1$ and $P_2 = m_2$ may be put into the balancing rings to eliminate the unbalance of the rotor.

The general procedure is to insert trial weights into the balancing rings till the value and location of P_1 and P_2 are discovered by systematic changing of these trial weights. Observation of the vibration with various trial weight combinations and "scribing" the shaft assist an experienced balancer in this work.

Assume a trial weight of q ounces screwed into the hole No. 2 of ring I, Fig. 2. This additional unbalance O_1A will combine with the original unbalance U_o and result in an unbalance U_1. Shifting the trial correction

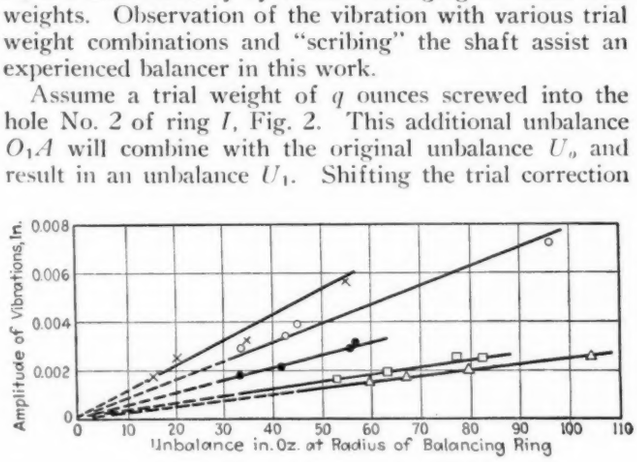


Fig. 3—Relation between amplitude of vibration and unbalance

weight from hole No. 2 to other holes will result in a variation of the unbalance, as shown in Fig. 2, where the weight q is shown also in holes 15 and 13 and a larger weight q_1 in hole 6. This results in unbalances U_2, U_3, U_4 at the end I, while the unbalance at end II remains constant.

It may be noticed that if the trial weight q is guessed correctly—that is, it is nearly equal to the original unbalance U_o—few trials will indicate distinctly the proper location of the correction weight P_1. But should the trial weight q be taken either much smaller or larger than U_o, the moving of q around the balancing ring will not produce a marked effect on the behavior of the rotor. This causes balancing at high speed to be at times a tedious process, requiring much experience and skill.

Observation of the diagram of Fig. 2 shows clearly that the ends of the vectors U_1, U_2 and U_3 are on a circle drawn from the end U_o of O_1U_o as a center, with the radius $U_oU_1 = O_1A$, the directions U_oU_1, U_oU_2 and U_oU_3 being parallel to the radii O_1A, O_1B and O_1C, respectively. In fact, it is seen that the diagram O_1DABC of the vectors of additional unbalances due to the trial weights is reproduced in the system $U_oU_4U_1U_2U_3$ having the end U_o of the vector O_1U_o as a center.

Vibration of the Bearing Pedestals

Alteration of the unbalance of the rotor produced by the insertion of trial balancing weights causes a corresponding variation in the vibration of the machine (occasionally the vibration might be entirely stopped by a "lucky move"). It is measured generally on the bearing pedestals, or at a point near the bearings where the unbalanced forces are applied to the structure. The amplitude of oscillation of the pedestal is rated by sense of touch or is measured by a suitable instrument, and the phase relation between the oscillation, and the position of the rotor, or the "high spot," is located by scribing the shaft at full speed or by some more elaborate device. It may be expected that the variation in the amplitude of oscillation is more consistent with the variation of the

unbalance than is the variation of the phase angle, since even in a simple vibrating system the phase relation between the motion of the system and the disturbing periodic force is quite complicated, while the amplitude is proportional to the magnitude of the force.

In this method of computing unbalance, amplitudes of bearing pedestal vibration observed for several trial weights are used. The assumption is made that the amplitude of a pedestal, say on end *1*, is proportional to the unbalance at the balancing ring *1*. This certainly cannot be laid down as a law, but it is an approximation quite sufficient for purposes of commercial balancing.

The accuracy of the assumption may be judged from results collected during actual hand-balancing of several turbine rotors and presented graphically in Fig. 3. In this figure the amplitudes of vibration of a pedestal are plotted against the unbalance at the nearest balancing ring. The conditions at the other end remained unchanged during the observations plotted. The unbalance vectors were found by composition of the additional unbalance caused by the trial correction weights and the original unbalance. This was taken to be equal and opposite to the final correction weight left in the rotor when the balance was found good. The points in Fig. 3

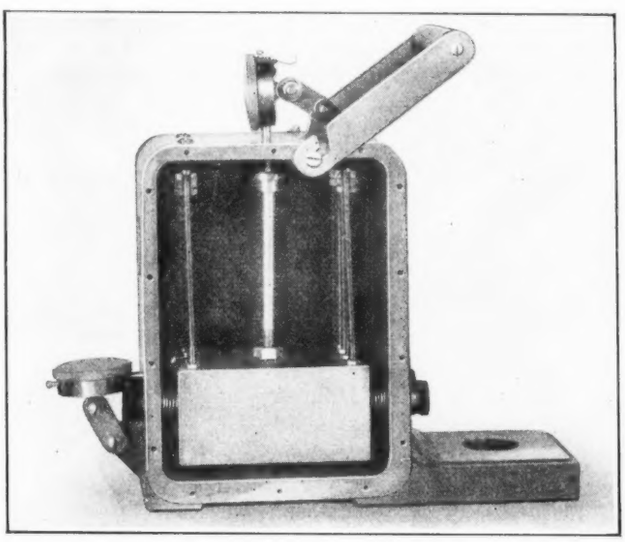


Fig. 4—Instrument for measuring amplitude of vibration

fall satisfactorily on straight lines through the origin *O*, thus indicating the truth of this proportionality relation.

It follows that the unbalance vectors in Fig. *2* give to a certain scale, the amplitudes of vibration of the pedestal, with the corresponding correction weight in the balancing ring. The scale, however, is certainly different for each individual machine. On the other hand, knowledge of the amplitude of vibration may give information on the unbalance of the rotor.

Vibrometer

In developing an instrument for measuring vibration, the aim was to build an apparatus that could be used not only as a portable vibrometer for balancing operations, but could serve as permanent equipment on power machinery, in order that the vibration of a unit could be under constant observation. A record of the vibration, kept along with the complete data of load, steam and temperatures, would be valuable to the engineer in handling power units of the size now in service. A numerical check of the vibration while coming up to speed when starting a machine is also useful. Such an instrument should be sturdy, reliable, easy to read and of long life.

A convenient form of vibrometer is shown in Fig. 4. A rugged frame is bolted to the vibrating machine part. A heavy block is suspended in the frame on eight coil springs. The block has a natural frequency of 200 cycles per minute in both vertical and horizontal directions and

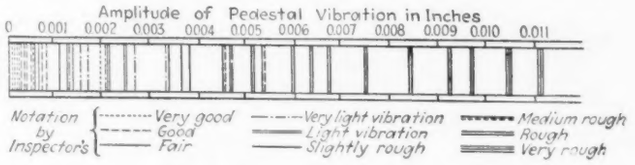


Fig. 5—Comparison of measured amplitudes and inspectors reports

is therefore practically immovable in space when subjected to a periodic disturbance of frequencies above 400 per minute.

Two high-speed dial indicators are rigidly mounted on the frame so as to be in contact with hardened polished plates on the block. The natural frequency of the dials is sufficiently high to insure their plungers following the block. The top indicator shows the amplitude of the vertical component of vibration, and the one on the side measures the horizontal component. They are graduated in half-thousandths, so that 0.0005 in. can be read on the dial and 0.0001 in. can be easily estimated. The hands of the indicators follow the oscillation of the vibrating body and their extreme positions on the dial define the magnitude of vibration. These can be seen distinctly, the velocity of a hand at the extreme position being zero. The dials proper can be rotated in their casings while the readings are taken; bringing zero in coincidence with one extreme position of the hand, the reading at the other extreme position gives directly the amplitude of the vibration.[2] This makes the instrument convenient in following the variation of amplitudes in both horizontal and vertical directions when starting up a unit, which is important if a complete picture of the vibration is required.

Lock screws are provided to make the block fast to the frame during transportation. A detachable handle permits one to carry the instrument around, and the machined lower surface allows it to be used for measuring vibrations of floors or other structural parts.

The dial indicators are provided with stops locking their plungers in an off-block position. This prevents continuous needless operation of the indicator mechanism when observations are not being taken, making the life of the instrument practically unlimited. The location of the dials outside of the housing provides easy inspection and adjustment of these vital parts of the vibrometer.

Amplitudes Observed

Several vibrometers of this type have been in service for a long period with satisfactory results. It is interesting to compare the indications of the instrument with notes on the vibration made by highly competent inspec-

[2]For simplicity the total motion of the pedestal is called the amplitude of vibration, although it should be called the double amplitude.

tors. Fig. 5 shows a diagram where the inspection notes are plotted against the amplitude measured by the vibrometer. These observations were collected at various occasions, on large turbines running at a speed of 1,800 r.p.m. On the basis of the observation a scale was worked out as given in the table:

VIBRATION SCALE

Inspector's Rating	Amplitude
Very good	0 —0.0003″
Good	0.0003″—0.0008″
Fair	0.0008″—0.0014″
Very light vibration	0.0014″—0.0020″
Light vibration	0.0020″—0.0028″
Slightly rough	0.0028″—0.0040″
Medium rough	0.004″ —0.006″
Rough	0.006″ —0.010″
Very rough	Above 0.010″

Fig. 5 shows how remarkably an experienced inspector can rate by sense of touch the magnitude of vibration; it also shows that the measured amplitude gives a fair criterion for judging the smoothness or roughness of the running of a machine.

It should be noted that observation of both the horizontal and vertical components of vibration is essential in judging the behavior of a machine. Depending on the construction of the foundation, a pedestal may have occasionally only a pronounced vertical vibration, the horizontal component being negligible. However, in general, an unbalance in a rotor results in pronounced horizontal oscillation, the stiffness of pedestals being less in this direction than in the vertical. It was found that the horizontal components are generally quite sufficient, within the accuracy required for commercial balancing, for computations of the unbalance. Only where the vertical vibration proves to be distinctly prevalent, should the balancing be done on the basis of the vertical amplitudes.

Turbulence vs. Large Furnace Volume

By L. W. Hayward*

MODERN furnaces are built with much larger furnace volumes than those found in installations fifteen or twenty years ago. The large furnace volume gives a long path of travel for the gases that are distilled from the coal and allows complete combustion to take place before the gases are cooled by the boiler below their ignition temperature. The size of the furnace required in order to obtain the best combustion efficiency, varies with the kind of fuel being burned and the method of firing. High-volatile coals require larger furnace volumes than low-volatile coals, and coal fired in the pulverized state requires larger furnaces than where the coal is burned on grates.

The results obtained from new installations with large furnaces were so pronounced that in old installations attempts were soon made to obtain similar results, but without the expense of radical changes in furnace design. These attempts have been successful to a large extent, for by the admission of air to the furnace at the proper points and at sufficient velocity to give proper mixing of the air with the gases distilled from the coal, marked improvements have been obtained. This has been demonstrated by various operating companies through the admission of air over the fire and by the use of steam jets to obtain the desired turbulence of the gases. The results have been so satisfactory that in designing new furnaces, the admission of air over the fire, to obtain this better mixing of gases and to supply the furnace with air where it is found to be deficient, is standard practice. Also, changes have been made in the shape of furnaces to obtain better mixing of the gases. Thus in addition to large furnace volumes it is also necessary to resort to proper turbulence to obtain complete combustion.

The conditions have been very similar when burning pulverized coal, and likewise the changes that have taken place have been guided partly by the results found when attempting to secure as high efficiencies from old installations as are obtained from the new installations. There is, however, one condition that is different, which has not been completely solved. In addition to obtaining complete combustion, it has been found necessary to burn completely in suspension the particles of fixed carbon.

Many old installations have been converted from stoker fired to pulverized fuel fired furnaces in order to obtain the high efficiencies that are being obtained from modern pulverized fuel stations. In most cases the furnace volumes were not changed, and the installations were not very successful by reason of the high fixed carbon and hydrocarbon loss. Later, by installing turbulent burners that gave a rapid mixing of the fuel and air, these small installations became much more successful, as the hydrocarbon loss was practically eliminated by this proper turbulence. The fixed carbon loss was still high—a condition not found in the small stoker fired furnaces.

The importance of obtaining a rapid mixing of the fuel and air, as well as the importance of the time element for completely burning the particles of fixed carbon, has been thoroughly demonstrated and recent installations are incorporating both in their design. The construction of the burner and furnace plays an important part inobtaining both these elements. We find installed in large furnaces, burners that give a long flame travel with little turbulence, which provide the desired time element. We also find installed in small furnaces, burners that give a very high turbulence, usually obtained by imparting to the coal and air a rapid whirling motion, giving the desired mixing but without the desired time element. The rapid whirling tends to separate the coarse particles from the finer by throwing the coarser particles to the cooler parts of the furnace, which limits their path of travel and the time they are in suspension.

To obtain both the time element for burning the fixed carbon and the turbulence for rapid mixing of the products of conduction, furnaces should be large enough to provide this necessary time element for burning the fixed carbon, and the burner should provide the necessary turbulence for the rapid mixing of the gases. The rapid mixing should not be accomplished without the required furnace volume, as it imparts to the coal a whirling motion, and such motion tends to separate the fine and coarse particles. However, turbulence is of value in shortening the time required to burn the volatile matter and hence reduce the tendency to smoke. Its value in reducing carbon losses, particularly at high combustion rates, is problematical, and on low-volatile coals it is possible that excessive turbulence due to 100 per cent air burners is detrimental to combustion of the fired carbon.

The experience obtained in burning coal in pulverized form has demonstrated that turbulence is of importance, but that the time element of combustion, which is determined by the furnace volume, is of greater importance.

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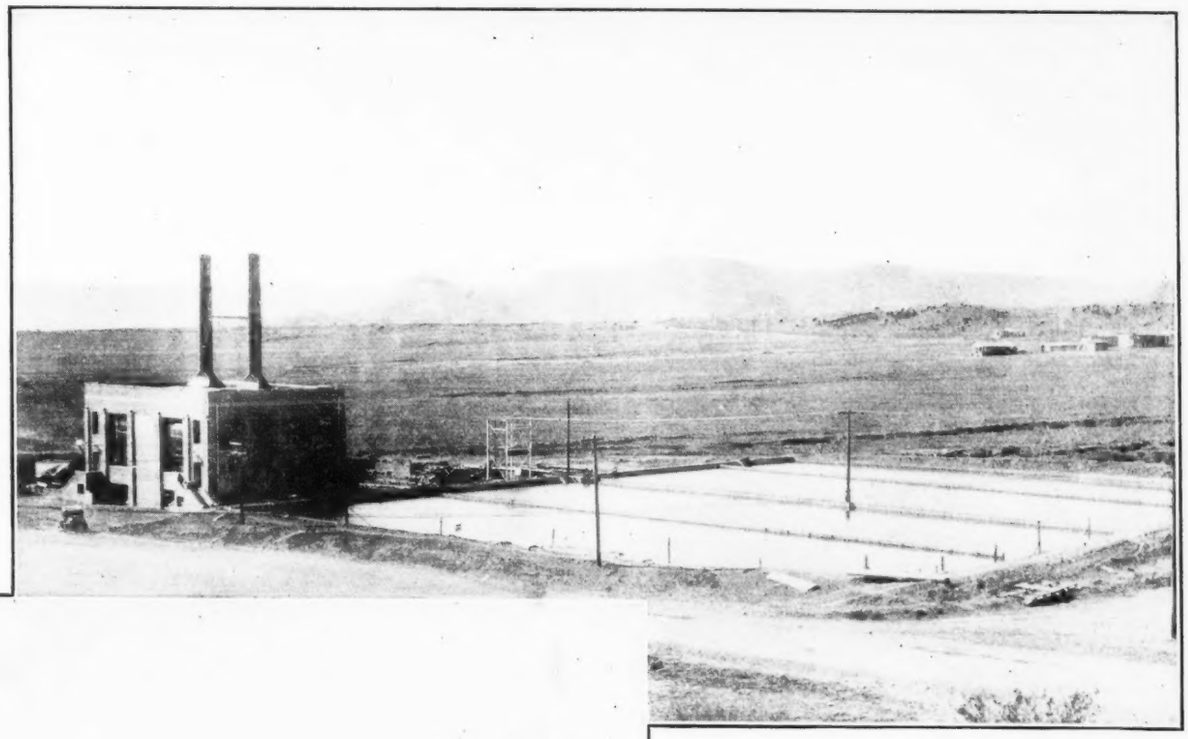
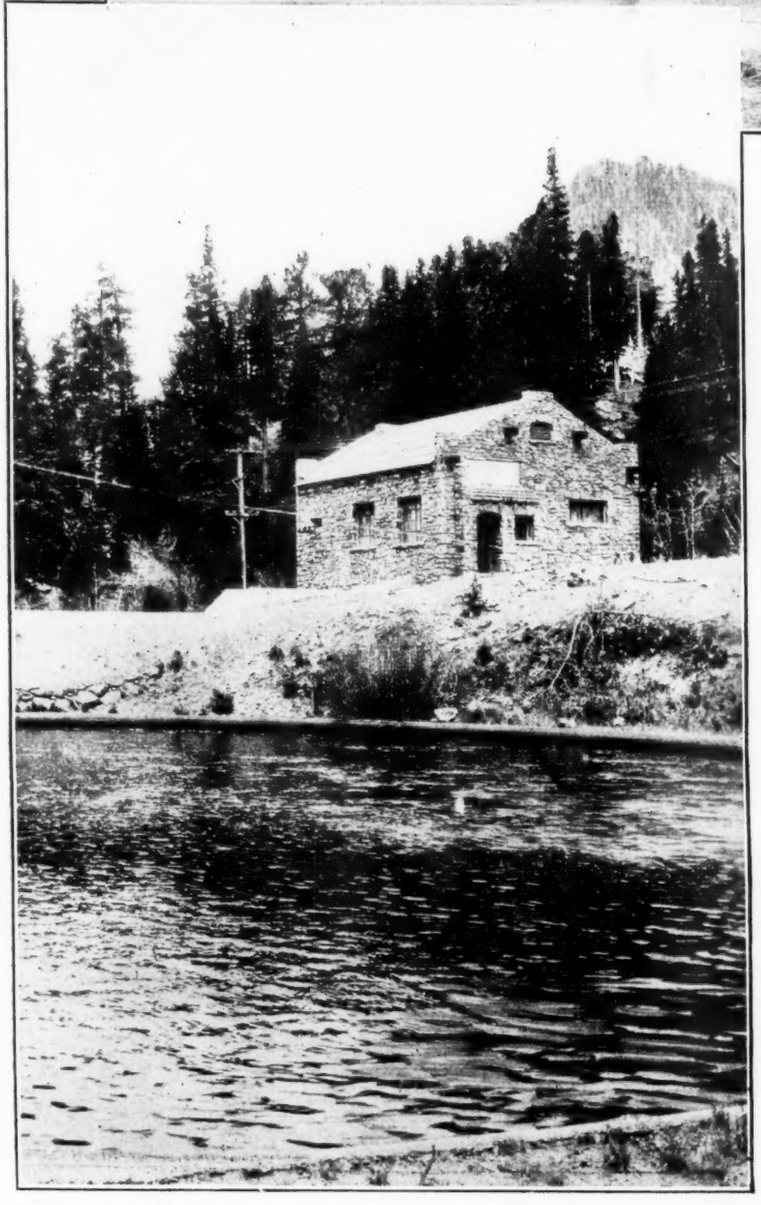


Municipal Bathing Pool at Raton, N. M.

Raton, New Mexico, has a municipal light plant, the condensing water of which is cooled in the pond shown above. The city authorities have rearranged the pool so that the Ratonians can disport themselves in the nice warm water. Since the mountain streams are too cold for bathing purposes, it is not unusual to find bathing beauties from as far away as Trinidad, Colorado, lending color and shape to the landscape.



An Engineer's Heaven

The building shown to the left is not the mountain lodge of a millionaire, but a hydro-electric plant of the Colorado Springs, Colorado municipal light system. Water for the city's water works is obtained in the mountains and on its way to the city is put through waterwheels in this plant. It is not difficult to keep an engineer here, for the fishing is good.

Combustion Control Formulas

VIII—Establishing an Equitable Bonus

By E. A. Uehling
M.E., Dr. of Engineering

A BONUS system, to be equitable, must benefit the employer as well as the employee. It must be based on the money value of the saving made by more than ordinary exertion of the employees. It must benefit the individual employee as nearly as possible in accordance with the saving resulting from his personal efforts. The bonus possible must offer sufficient inducement to make it worth the extra effort necessary to earn it.

To illustrate the operation of such a system, assume its application to the operatives of an industrial power plant consisting of five boilers each containing 5,000 sq.ft. of heating surface. Four of the boilers are in continuous operation, one off for cleaning and repairs. The units are of the water-tube type, modern setting and hand-fired. The fuel is bituminous coal of good quality. The full equipment of instruments necessary for economic control having been installed a sufficient length of time to produce the desired economic effect, it is assumed that the average of the recorded data have been: $CO_2 = 12$ per cent, $CO = 10$ per cent, $T = 565$ deg. F., $Bd = 0.30$ in. of water, $S = 200$ lb. gage. The corresponding heat loss factors are $X = 5.11$ B.t.u., $Y = 0.008$, $T = 565$ deg., $\sqrt{Bd} = 0.55$. These are, then, the average control factors produced by the operating personnel with ordinary good care and effort; and may be called the basic heat-loss factors.

> THE analysis of the heat loss components given in Articles VI and VII of this series, are used in this installment to develop an equitable bonus system.

Now let it be assumed that under the conditions prevailing NCO_2—that is, the normal per cent of CO_2 as defined in the previous article—was found to be 14 per cent and that the relation between NT and $N\sqrt{Bd}$ was found to be as follows:

$N\sqrt{Bd}$	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90	1.00
NT	400	430	460	490	520	550	580	610	640	670

NCO_2 is practically constant, but NT varies with the $\sqrt{Bd}$, which depends on the per cent of CO_2 and the rate of combustion.

It is further assumed that the average data recorded simultaneously with $NCO_2 = 14$ per cent are as follows: $NCO_2 = 14$, $NCO = 0.20$, $NT = 510$ deg. and $NBd = 0.22$ in. of water. The corresponding normal heat-loss factors are $NX = 4.42$ B.t.u., $NY = 0.014$, $NT = 510$ deg. and $N\sqrt{Bd} = 0.47$. If properly determined, NX and NY will serve as the standard minimum heat-loss factors so long as there is no material change in the operating conditions. For the average load $NCO_2 \times N\sqrt{Bd} = 14 \times 0.47 = 6.58$ the index of the average of driving established by test. Let us also assume that the tests have established the normal relation between CO_2 and CO to be: CO_2, 12, CO, 00; CO_2, 13, CO, 0.10; CO_2, 14, CO, 0.20.

To produce the normal efficiency—that is, the maximum maintainable efficiency as established by test—the firemen must exercise their utmost skill and vigilance, the boiler cleaners must work with great care and regularity and the operating engineers must see to it that their men are supplied with everything necessary and give them every assistance possible. It is only human nature that, unless a worth-while incentive is offered, the extra effort required to maintain the practical maximum efficiency will not be forthcoming. Inserting the assumed numerical values of X, NX, T and Y and NY in the formula, $(X - NX) \times T + 10{,}160 \times (Y - NY)$, we have $(5.11 - 4.42) \times 565 + 10{,}160 \times (0.008 - 0.014) = 390 - 61 = 329$ B.t.u. loss of heat that could have been saved by the firemen. And substituting the values of T, NT and NX in the formula, $(T - NT) \times NX$, we have $(565 - 510) \times 4.42 = 243$ B.t.u. of heat loss that could have been saved by the boiler cleaners. Thus, if both firemen and boiler cleaners make bull's-eye hits, the fuel consumption will be decreased $\frac{329 + 243}{17{,}900} = 3.2$ per cent. Of this savable loss $\frac{329}{17{,}900} = 1.84$ per cent is due to excess air, for which the firemen are responsible, and $\frac{243}{17{,}900} = 1.36$ per cent is due to excess temperature, for which the boiler cleaners are responsible. The bonus must be based on the money value of the fuel saved. Thus, if the four boilers operating continuously 24 hours a day and 6 days a week consume an average of 600 tons of coal costing $5 a ton, the cost of the fuel before inaugurating the bonus would be $5 \times 600 = \$3{,}000$ a week. Of this it is possible to save 3.2 per cent by the extra effort the bonus is expected to stimulate, which amounts to $96 of possible saving per week over the average cost of fuel before the bonus was inaugurated. Thus, if all hands hit the bull's-eye, the employer will be $96 ahead on his weekly coal bill. This, then, would be the maximum sum available for the bonus. The actual sum will vary between the maximum and zero.

As the boilers are hand-fired and in operation 24 hours a day, the operating personnel would consist of 12 firemen, 3 boiler cleaners, 3 operating engineers, 1 chief engineer and 1 assistant to the chief. The duty of the last mentioned would be to keep the instruments in working order, integrate the records, calculate the results and keep a comprehensive record of all the economic data and results.

In a power house of 2,000 hp. the duty of the operating engineers would be divided about equally between boiler room and engine room. The wages of the operating personnel affected by the bonus would be as in Table I:

TABLE I—LABOR COSTS

Firemen, 12, at $40 per week	$480.00
Boiler cleaners, 3, at $35 per week	105.00
Operating engineers, 3, at $50 per week, ½ time charged to boilers	75.00
Assistant to chief engineer	35.00
Total weekly wages affected by bonus	$695.00

The chief engineer's salary should not be affected by the bonus, so that he will be quite impartial in distributing the bonus earnings. His salary should be sufficient to stimulate his efforts to maintain maximum efficiency.

Amount Paid as Bonus

If all hands hit the bull's-eye, there will result a saving in the cost of fuel of $96, or $\frac{96 \times 100}{695} = 13.81$ per cent of the wages entitled to a bonus. On this showing the proprietor need not be especially liberal minded to conclude that he could afford to pay his boiler operating personnel a bonus of 10 per cent on their respective wages. The maximum bonus would be 10 per cent of $695 = $69.50, and the maximum saving would be $96 a week.

Thus, after paying this maximum bonus to the men taking part in earning it, there would be a weekly surplus of $96 — $69.50 = $26.50 for the proprietor. A 10 per cent bonus would be quite worth while for the men to make the extra effort necessary to earn it and at the same time be profitable to the employer, who would benefit indirectly to a greater extent than directly, because of the increased operating efficiency.

To be equitable, the bonus received must bear a true relation to the saving due to the efficiency of the person receiving it. This relation can be determined very closely for the firemen and boiler cleaners. The bonus falling to the operating engineers is equitably earned by seeing to it that the firemen and boiler cleaners are provided with everything required for efficient operation and promptly assisting them over difficulties when they arise. The assistant is entitled to his share of the bonus if he keeps the instruments in perfect running order, promptly calls the attention of the chief engineer to any irregularities that the records may reveal and keeps the heat loss calculations up to date.

The 10 per cent bonus is earned only when bull's-eye hits are made. The per cent actually earned will vary for each individual operator between the lower average and normal limits of efficiency established by tests.

When the upper limit of efficiency is attained, there is no loss of savable heat, hence the full bonus has been earned. When the efficiency falls to the lower limit, the maximum permissible loss obtains, hence no bonus has been earned. The total bonus earning, under the assumed operating conditions, will vary between these limits—between $69.50 and nothing. To be equitable, each operator must receive as nearly as possible that part of the total bonus he has actually earned.

Under the assumed operating conditions the firemen saved 329 B.t.u. and the boiler cleaners saved 243 B.t.u. per pound carbon unit of coal burned, when making bull's-eye hits. Now if we let A = the heat it is possible to save by an individual fireman and B = the savable heat that he wasted, then $A - B$ = the heat he saved, hence $\frac{A - B}{A} \times 10$ = the per cent bonus to which he is entitled. Thus, if he makes a bull's-eye hit, there is no savable loss and B = zero, then $\frac{A - O}{A} \times 10 = 10$, and he has earned and is entitled to a 10 per cent bonus. If B is equal to A, then $\frac{A - B}{A} \times 10 = \frac{0}{A} \times 10$ = zero bonus. If B is greater than A, then, $\frac{A - B}{A} \times 10$ = a minus bonus, that is, the bonus becomes a penalty. If, then, the bonuses are calculated according to this formula, the firemen and boiler cleaners will receive bonuses in direct proportion to the saving in fuel they make. There are, however, other factors that will affect the bonus of the firemen and must be taken into account; for example, the loss through the grate and the rate of combustion of which latter $CO_2 \times \sqrt{Bd}$ is the index. The operating engineer, being also responsible for the efficient performance of the boilers and appurtenances, receives an equitable bonus if the per cent is the average of that of all his men. The assistant to the chief is equitably entitled to a bonus $\frac{P}{100} \times 10$ per cent of his wages, where P is the per cent of efficiency of his performance based on the performance of the instruments under his care, his proficiency in keeping the records correctly and up to date, and especially in calling the chief's attention to abnormal changes in any of the records.

Data Required to Compute Bonus

To be able to calculate the bonus for each participant, a complete daily record of the average of the graphically recorded performance must be kept. This record must contain: First, the average CO_2, CO, T and Bd; second, the corresponding heat loss factors X, Y and $\sqrt{Bd}$; third, the standard factors, NX, NY, NT and $N\sqrt{Bd}$; fourth, the index of the rate of driving $CO_2 \times \sqrt{Bd}$; and fifth, the savable heat losses F and B, calculated by Formulas 1, 2 and 3. Table II illustrates the records and results of one boiler for one day.

From Table II it is seen that fireman John produced an average of 13.8 per cent of CO_2, the corresponding X of which is 4.49, $NX = 4.42$ and $T = 535$, hence $(X - NX) \times T = (4.49 - 4.42) \times 535 = 37$ B.t.u. The gas contained 0.25 per cent CO, the corresponding Y of which is 0.018. According to the normal relation between CO and CO_2 established by test, CO should not have exceeded 0.18 per cent to which $NY = 0.013$ corresponds. Inserting these values of Y and NY in Formula 2, we have $(0.018 - 0.013) \times 10{,}160 = 51$ B.t.u.;

therefore John wasted $37 + 51 = F = 88$ B.t.u. of savable heat.

The average BD was 0.25 and $\sqrt{Bd} = 0.5$. According to the normal relation between $\sqrt{Bd}$ and T when $\sqrt{Bd} = 0.50$ is $NT = 520$; therefore, $(T - NT) \times NX = (535 - 520) \times 4.42 = B = 66$ B.t.u. wasted by boiler cleaner Tim.

Making the same calculations for the other two firemen and boiler cleaners, the heat results as given in Table II are obtained. Inserting the values of A and B in formula $\frac{A - B}{A} \times 10$, we find the bonuses to be as follows:

John: $\frac{329 - 80}{329} \times 10 = 7.57$ per cent

Jack: $\frac{329 - 153}{329} \times 10 = 5.35$ per cent

Bill: $\frac{329 + 129}{329} \times 10 = 13.88$ per cent

Tim: $\frac{243 - 66}{243} \times 10 = 7.28$ per cent

Joe: $\frac{243 - 105}{243} \times 10 = 5.72$ per cent

Tom: $\frac{243 - 0}{243} \times 10 = 10$ per cent

The bonus to which a fireman is entitled may be greater or less than the foregoing, depending on whether he

TABLE II—OPERATING DATA FOR ONE BOILER

Shift		Per Cent 1	2	3
Fireman		John	Jack	Bill
Average recorded data	CO_2	13.8	12.8	14.2
	CO	0.25	0.00	0.15
	T	535	550	500
	BD	0.25	0.27	0.18
Heat-loss factors	X	4.49	4.81	4.36
	Y	0.018	0.08	0.005
	T	535	550	500
	$\sqrt{Ba}$	0.50	0.52	0.42
Standard heat loss factors	NX	4.42	4.42	4.42
	NY	0.013	0.006	0.0146
	NT	520	526	500
	$N\sqrt{Bd}$	0.47	0.47	0.47
$CO_2 \times \sqrt{Bd}$ = Index of Combustion		6.90	6.66	5.96
$NCO_2 \times N\sqrt{Bd}$ = Normal Index		6.58	6.58	6.58
Heat losses by firemen:				
1, $(X - NX) \times T$		0.37	214	— 30
2, $(Y - NY) \times 10{,}160$		0.50	—61	— 98
1 + 2 = Savable loss F		80	153	—128
Heat loss by boiler cleaners:		Tim	Joe	Tom
3 $(T - NT) \times NX$ = Savable loss B		66	105	00

contributed his full share toward the production of the steam produced. Since the $\sqrt{Bd} \times CO_2$ is the index of the rate of combustion, $\frac{\sqrt{Bd} \times CO_2}{N\sqrt{Bd} \times N\,CO_2}$ will be a comparative measure of the fireman's diligence and therefore of the wages he actually earns. Applying the formula to the fireman John's work as recorded in Table II, we have

$$\frac{\sqrt{Bd} \times CO_2 \times \text{rate of pay}}{N\sqrt{Bd} \times N\,CO_2} = \frac{6.90 \times 40}{6.58}$$

$= \$41.88 =$ rate of pay actually earned that day.

The same calculation shows that Jack's earnings were at the rate of $\frac{6.66 \times 40}{6.58} = \$40.48$ per week.

Bill's earnings would be at the rate of $\frac{5.96 \times 40}{6.58} = \$36.23$ per week.

The formula $\frac{A - B}{A} \times$ standard bonus evaluates the care and intelligence exercised by the fireman, and the ratio of $\frac{\sqrt{Bd} \times CO_2}{N\sqrt{Bd} \times N\,CO_2}$ evaluates his industry.

To be equitable, the bonus paid must be based on the combined result of the industry, care and intelligence exercised by the fireman. The money value of the bonus payable is therefore the per cent earned by care and intelligence of the wages earned by industry. Fireman John increased the rate of his weekly wages by extra industry from $40 to $41.88. He earned a bonus of 7.57 per cent by exercising care and intelligence. He is therefore actually entitled to a weekly rate of $41.88 +$

TABLE III—BONUS SCHEDULE

Final Record Data

Shift	Boiler No. 1 — 1	2	3
Fireman	John	Jack	Bill
	Per Cent Bonus Earned		
Monday	10.25	6.62	3.02
Tuesday	8.53	7.25	5.25
Wednesday	9.30	8.50	7.50
Thursday	7.90	8.75	8.35
Friday	8.25	7.90	9.10
Saturday	9.46	8.30	9.87
Average for the week	8.95	7.88	7.18
Boiler Cleaners	Jim	Joe	Tom
Monday	7.28	5.72	10.00
Tuesday	8.70	7.30	8.20
Wednesday	9.20	6.80	9.37
Thursday	9.86	8.25	8.43
Friday	8.40	7.15	7.75
Saturday	7.59	6.80	8.40
Average for the week	8.50	7.00	8.69

$41.88 \times 0.0757 = \$44.05$. Fireman Jack is entitled to $40.48 + 40.48 \times 0.0535 = \$42.65$, and fireman Bill is entitled to $36.23 + 36.23 \times 0.1388 = \$41.26$.

Thus we see that Bill lost the major part of his bonus earned by intelligence because of his indolence, which shows how important it is to evaluate industry in the boiler house as well as care and intelligence. The loss of fuel through the grate is also an economic factor that should be taken into account. But since there is no ready method of determining the loss through the grate, its evaluation must rest with the judgment of the engineer. The relation of the industry and intelligence of the boiler cleaners must also be left to the judgment of the engineer.

The daily bonuses are recorded for the week in Table III. The bonus per cent for the operating engineer is the average of that of the men under him. John and Tim are under engineer Brown, which entitles him to $\frac{8.95 + 8.50}{2} = 8.72$ per cent bonus; Jack and Joe are under engineer Smith, hence he is entitled to $\frac{7.88 + 7.00}{2} = 7.44$ per cent bonus; Bill and Tom are under engineer Kelly, hence his bonus is $\frac{7.18 + 8.69}{2} = 7.94$ per cent.

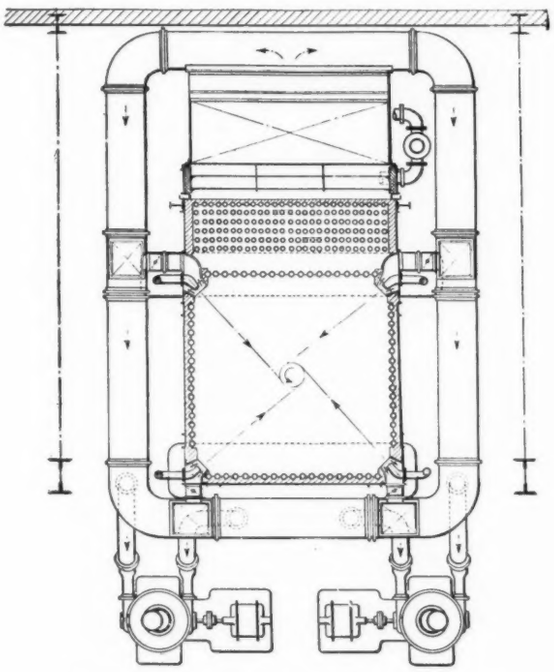
The bonus of the assistant to the chief engineer must depend on his efficiency in taking care of the instruments under his care and on the accuracy and promptness in keeping the records. He earns his 10 per cent bonus if he keeps all the instruments recording continuously and accurately and keeps the records up to date.

The Steam Generator in Service

By GARRETT BURGESS
Chief Engineer, United States Rubber Co., Morgan & Wright Detroit Plant

THE ideal steam generator, in the author's opinion, would provide a high average heat transfer rate for all surfaces. To effect this condition, it would be necessary that every tube receive the maximum heat effect. First, by radiation due to exposure to radiant heat; second, by convection due to furnace gases sweeping all surfaces. However, if heat is to be rapidly absorbed, it must be rapidly generated. The intimate mixture of fuel and air secured by turbulence in the furnace greatly accelerates combustion and permits a reduction in excess air. Hence, there is a definite trend toward turbulent action in the design of pulverized fuel burners and furnaces. The increased combustion rates thus secured permit either higher ratings or smaller furnaces.

AT THE Morgan & Wright plant of the United States Rubber Company, Detroit, there are installed two combustion steam generating units. The first went on the line in March of last year. The drawings here reproduced show the general arrangement and emphasize the compact design which was necessary to adapt so small an available space to a large steaming capacity.



Plan showing turbulent effect in furnace

Steam generator in course of erection

The features incorporated in the steam generator are: (a) Full water-cooled combustion-chamber walls integral with the circulatory system of the generator, (b) practical elimination of brickwork in the furnace, (c) water-screen, (d) tangential firing. The roof and four side walls of the combustion chamber are of the finned-tube type, the tubes being 4 in. in diameter, placed on 7-in. centers. These tubes are backed by light tile sections laid up dry, behind which is 1½ in. of rock-wall insulation and an outside metal casing.

At maximum rating these steam generating units are designed for a liberation of over 34,000 B.t.u. per cubic foot of furnace volume. The heat liberation on Nov. 8, which showed the highest evaporation, was equivalent to 31,500 B.t.u. per cubic foot of furnace space per hour. Similar generators have been operated successfully at rates as high as 50,000 B.t.u. per cubic foot. The resulting high temperatures are in excess of the fusing point of the ash, hence a water screen is provided to prevent the molten ash particles from fusing together into a solid agglomerate mass as they fall into the hopper below the combustion chamber. This screen consists of six rows of 3-in. plain tubes.

Pulverized coal is introduced through eight burner nozzles located in the four corners near the top of the combustion chamber (see plan). The burners are so pointed that the incoming streams of coal and air lie tangent to an imaginary circle, with the result that rapid rotation of the furnace gases takes place. Air coming in around the burners is quickly cut by the rotating

gases, and intimate mixture takes place before segregation can occur. This feature is of considerable importance since even preheated air is dense compared with the hot gases in the combustion chamber and, unless quickly mixed by turbulence, will fall rapidly out of the combustion zone without serving in the combustion.

These steam generating units are each rated at 100,000 lb. evaporation from and at 212 deg., but are guaranteed to deliver 120,000 lb. as a maximum maintained rating. With feed water at 210 deg. F., a drum pressure of 205 lb. and a total steam temperature of 550 deg., these figures correspond to actual outputs of 87,500 and 104,350 lb. respectively. No attempt has been made to date to carry out a sustained capacity test. Evaporation of 100,000 lb. per hour, actual over a period of an hour, is common, and this capacity can be exceeded if necessary. Performance records for a ten-day period, give the operating results shown in the table.

All pressure parts are supported from above by means of four U-bolts. This construction affords complete freedom for expansion and permits temperatures to be quickly raised.

Referring to Fig. 1, air for combustion enters the forced-draft fan, passes downward through the air preheater and into the duct which encircles the generator. From here it enters the ports around the burners. Air is also drawn from this duct to supply the pulverizing mills. The air-preheater is designed to deliver air to the duct at 636 degrees.

The superheater is of the vertical type and is proportioned to deliver steam at 550 deg. at maximum rating. This corresponds to a superheat of 160 degrees.

The draft fans are operated by slip-ring induction motors with controls proportioned to give a variation from half-speed to full-speed, and dampers are provided which may be operated from the main floor electrically.

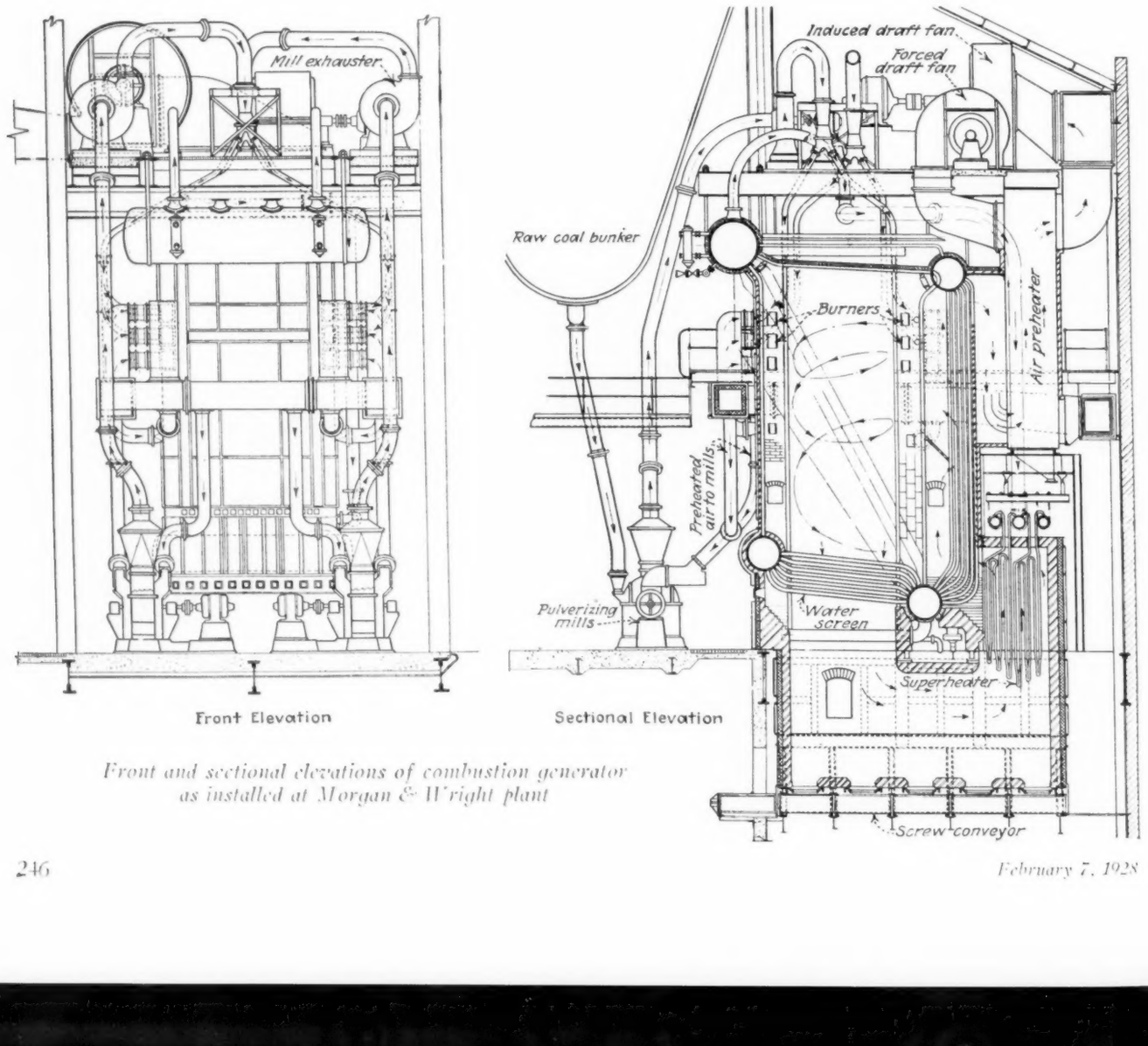
DAILY PERFORMANCE RECORDS

Date	Evaporation—Thousands of Pounds Actual	Evaporation—Thousands of Pounds Equivalent	Coal Consumed Lb. per Hour	Coal as Fired B.t.u. per Lb.	Efficiency
11–1–27	90.4	106.0	9,100	12,810	88.1
11–2–27	89.3	104.5	8,900	12,890	88.4
11–3–27	81.2	95.0	8,130	12,940	87.6
11–4–27	85.5	100.2	8,780	12,720	86.8
11–5–27	Week-end boiler off line				
11–6–27					
11–7–27	91.3	106.7	9,280	12,860	86.8
11–8–27	95.1	111.5	9,370	12,920	89.3
11–9–27	90.4	105.8	8,930	12,830	89.5
11–10–27	84.2	98.4	8,500	12,870	87.5

Note: These figures are averaged from 16 hr. daily operation.

Each steam generator has two independent coal systems, consisting of feeder and mill, exhauster, distributor, burner piping and burners. When operating on a single mill, 60 per cent of the full load rating may be attained.

Crushed coal is stored in a suspension bunker and delivered to the feeders, which are integral with the mills, through a weigh scale which automatically records the weight consumed. From the mills the coal is picked up by the exhausters, located above the unit, and passed through distributors to the burners. The mills are



Front and sectional elevations of combustion generator as installed at Morgan & Wright plant

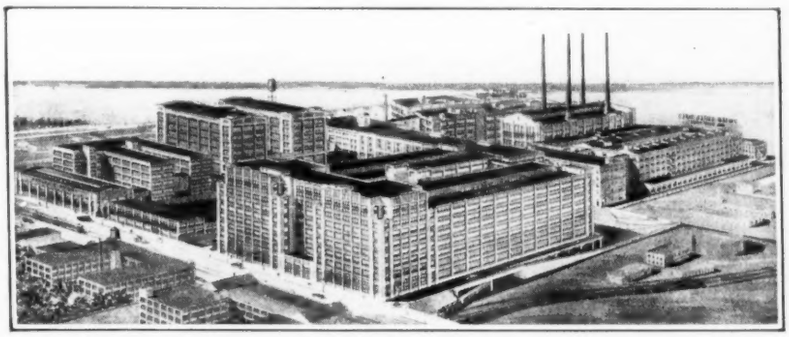
equipped with fineness regulators which make possible the control of the degree of pulverization and assure uniform fineness.

A complete electrical interlock insures proper sequence of operation in starting and safeguards the equipment in case of enforced shutdown. Control is from a glass-inclosed room between the two generators. From this point of vantage a single operator is in a position to know at all times the conditions obtaining and to make such changes and adjustments as may be required.

On the control board have been installed the indicating and recording instruments necessary to give the operator a complete knowledge of the conditions existing. These include an indicating and integrating electrically operated feed-water flow meter; indicating, integrating and recording electrically operated steam-flow meters; recording and indicating steam pressure gages; indicating ammeters showing the load on each pulverizer, exhauster and fan unit; multi-pointer draft gage; electrically operated CO_2 recorder; electrically operated multi-point pyrometer recording gas temperature entering and leaving air preheaters, preheated air temperature and total steam temperature; and a two-pen recording temperature gage, showing the temperature of the coal leaving the pulverizers.

In addition to these instruments the board is equipped with suitable mechanisms for manual operation of the units, which are not yet equipped for automatic control. If found desirable, automatic control will be provided at a later date.

Push-button stations, with indicating lights, are provided for starting and stopping motors and for operating the main dampers on the forced- and the induced-draft fans; mechanical devices permit adjustment of coal feed to the pulverizers and auxiliary air for tempering the primary preheated air to the pulverizers. These complete the controlling apparatus.



View of Morgan & Wright plant; power house in background

Despite the apparent complexity of the unit itself, together with the controlling apparatus, operation is surprisingly simple. Bringing the unit on the line from "cold," requires the following operations:

The fans are started and the dampers adjusted to hold approximately 0.3 in. induced draft, and zero pressure on the forced draft in the furnace. Pilot lights on one set of burner nozzles are lighted (artificial gas direct from city mains is utilized for this purpose). One pulverizer unit is now started with the auxiliary dampers closed and no air circulating through the pulverizer. Coal feed is increased until the mill is loaded to approximately 60 amperes. (These mills are of $3\frac{1}{2}$ tons per hour capacity, each driven by a 75-hp. induction motor). Air supply is then gradually increased with the coal feed until the unit is on line. The time between "starting" and "on line" is usually from thirty to forty minutes, although if necessary this time may be cut to less than half.

When the generator was first put into service, one of the roof tubes ruptured and had to be replaced before regular operation could be resumed. An examination of the tube that failed, showed it to be of laminated structure, which accounted for the difficulty.

Aside from minor changes to baffles, etc., there have been no changes in construction from the original design.

A final, and not inconsiderable, advantage of the new steam generator is the absence of banking losses. Referring to the table of operating efficiencies heretofore given, it is to be noted that the efficiencies given resulted despite the fact that the unit was taken off the line during the third shift each day. No coal was consumed during the eight hours off the line, and the amount of coal required to bring the unit back on the line from cold is insignificant. This absence of banking losses is particularly noticeable over week-ends when the total load on the plant is comparatively low.

British Power House Utilizes Furnace Waste Gas

THE plan inaugurated by the late Charles Markham, chairman of the Staveley Coal & Iron Company, for the installation of gas engines for the generation of electricity for power and lighting purposes for his firm's works and a ring of collieries, has just been completed, the third gas engine, of 7,000 hp., having just been given a trial run. The three engines in the plant, the largest in the United Kingdom, are of Belgian manufacture, although a large portion of the material in the shape of forgings and castings were made in Sheffield.

The great economy of the plan is that the gas engines burn waste gas from the blast furnaces owned by the company. The company now has approximately an output of 60,000,000 kw.-hr. annually and current is sold in bulk to neighboring local authorities. Several neighboring villages take their supply of current for lighting from the company, while all the iron works and collieries of the company obtain power and light from the new installation.

The third engine differs from the two tandem engines originally installed in that it is connected to a 50-cycle generator running at 94 r.p.m., while the other units have 30-cycle generators. In addition there are two 2,500-kw. reversible synchronous frequency changers, which enable the plant to deliver either 30- or 50-cycle current, or both.

Burning Hog Fuel *in the* Pacific Northwest

By O. L. LeFever

General Superintendent, Northwestern Electric Company, Portland, Ore.

From oil to hog fuel for power generation. Its possibilities and limitations and some of the requirements for successful burning

POWER generation for electric utilization in each succeeding decade passes through phases that are only partly visioned by the preceding one. Here in the Pacific Northwest, previous to the World War, fuel oil with 18,000 B.t.u. per lb., was available to barges for 72c. per 42 gal. barrel. Seaboard plants were able to show a handling cost from barge to the furnace burner not in excess of 8c., making a total fuel cost at the burner of 80c., or a kilowatt-hour cost for fuel only from 2.3 to 3.5 mills, depending on plant efficiency.

The chaotic conditions brought about by the War caused fuel oil to rise in price to $2.50 per barrel. Power generation with this type of fuel under prevailing tariffs was prohibitive. This caused utility executives to plan for some substitute. Hydro power at reasonable costs was available, but could not be developed with sufficient rapidity to meet the immediate demand. Lumber in Oregon and Washington was being cut at the rate of about 12 billion ft.b.m., per annum. The wood waste attendant in the production of this lumber, over and above the mill's own requirements, amounted to about 12 million tons per annum, which was disposed of by the mills in incinerators.

Engineers studying the problem saw in this type of fuel the solution to their problem. Here was a vast economic waste of fuel that surely could be made available at extremely low first cost. It was recognized that the burning of this type of fuel would require a furnace considerably different from one used for coal. Past experience and research caused engineers to decide on the extension type of furnace called a Dutch oven.

Characteristics of Hog Fuel

As many engineers are not familiar with the use of wood waste for steam generation, it will be well to set forth some of the terms used in connection therewith, after which the reasons for the adoption of the Dutch oven will be developed.

To facilitate the handling of wood waste, it is passed through a chipping machine called a "hog," which gave rise to the term now applied to such fuel. In addition to the cut fuel or chips, commercial hog fuel includes sawdust and planer shavings. The standard measure for hog fuel is called a "unit" and consists of 200 cu.ft. by volume. A cord of wood is approximately equal to one unit of hog fuel. It was from this source that the unit of measure started.

About 75 per cent of the fuel available in the district under consideration consists of Douglas Fir, an ultimate analysis of which when dry is about as follows: Carbon, 50 per cent; hydrogen, 6 per cent; oxygen, 43.1 per cent; nitrogen, 0.4 per cent; ash, 0.5 per cent. Fir contains about 81.5 per cent volatiles, 18 per cent fixed carbon and 0.5 per cent ash. The high percentage of volatiles makes large combustion space imperative in order to secure a proper mixing with the oxygen of the air and to allow time for the mixed gas to reach the ignition temperature before coming in contact with the tubes.

The average moisture content in fuel received from the producing mill is about 40 per cent. To secure good combustion the moisture in the fuel must be evaporated rapidly. Radiant heat from the brickwork is the most important factor in speeding up this operation in the burning cycle. Hence, the more brickwork adjacent to the furnace fuel pile the more rapid the evaporation from the fuel.

Burning Hog Fuel in Dutch Oven

Fig. 1 shows the furnace most commonly used for larger boilers. The best burning conditions are secured by placing dividing walls in the furnace between each set of two longitudinal firing holes. It is important that the location of the firing holes be so calculated as to have all grate surface covered when the load on the boiler is light.

It will be noticed from a study of Fig. 1 that the fuel in the furnace will form cones underneath each firing hole. The best results are obtained with the type of furnace shown by maintaining a cone height about 18 in. below the top of the furnace. This results in surface burning, with little air coming through the grates excepting around the edges, and prevents the introduction of preheated air below the grates, as the temperature would become so high as to cause warping. Preheated air may be supplied at or near the front door with good results.

Hog fuel contains all the bark from the logs, and as most logs are placed in streams or ponds at some time during their journey to the mill, considerable sand is carried into the furnace and forms a hard glass-like clinker. Under heavy firing conditions with the foregoing type of furnace, it is necessary to clean grates once in 24 hours. This is an objectionable feature when boilers can be off the line only for short periods, as

opening up the front doors allows cold air to come in contact with the highly heated furnace walls and is detrimental to the setting.

To obviate this condition and to permit of the major portion of the air passing through the grates for combustion purposes, a furnace with a sloping grate, as shown in Fig. 2, was designed. This type works out well when used with small boilers having a uniform grade of well hogged fuel. With large boilers the restricted furnace volume is objectionable. Also the larger users of hog fuel generally procure it from several different

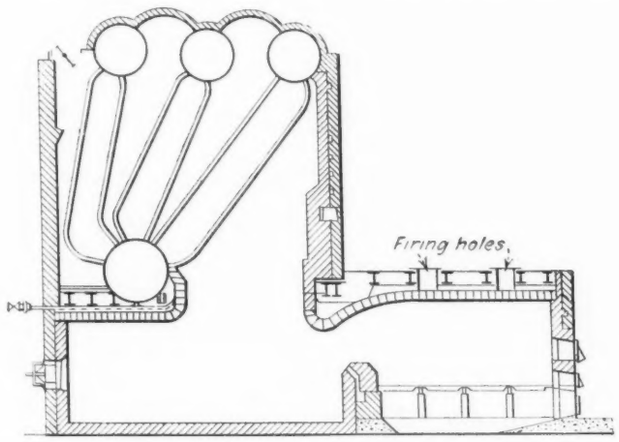


Fig. 1—Typical drop-nose furnace used with the larger boilers

mills that supply fuel widely different in character. Poorly hogged fuel will hang up on the grates at times and avalanche, thus tearing holes in the fire. Coarse fuel fed for a time and then followed by a finer grade, or vice versa, calls for constant attention from the fireman to maintain steady steaming of the boiler.

Transportation of Hog Fuel Limited to 100 Miles

On account of the bulkiness of hog fuel and the fact that a pound of it as fired averages only about 4,500 B.t.u., it cannot be transported long distances by rail and compete successfully with power from hydro plants. All utilities using large quantities of hog fuel have their plants situated on navigable water and transport their fuel on barges from mills similarly located. Fuel prices for the last few years have fluctuated from $0.50 to $1.50 per unit loaded on the purchaser's barges at the sawmill. With the highest price prevailing, fuel can be transported by barges about 100 miles and still have a fuel cost including handling charges not to exceed 5 mills per kw.-hr.

Fixed charges on hydro plants, as compared with steam plants, vary widely with the hydro project under consideration, but in general any fuel cost of 5 mills or greater would show in favor of the hydro.

While the amount of mill refuse produced is tremendous, the fact that the mill must be on navigable water within a distance not to exceed 100 miles from the consumer, limits this class of fuel to a small percentage of the whole. Herein is introduced a factor limiting hog-fuel steam-plant developments to the amount of fuel available in that district.

Executives contemplating hog fuel plants are also faced with another uncertainty, which is the degree of utilization that will take place in manufacturing processes, such as wall board, balsam wool for refrigerators, kraft paper, base for blasting powder, etc. The amount of fuel that will be so diverted in the future cannot be foreseen, but the uncertainty will cause hog-fuel steam-plant development to stop somewhat short of the available supply of fuel.

Any fluctuation in the production of lumber causes a like fluctuation in the hog fuel supply. Seasonable fluctuations are taken care of easily by providing outdoor storage, but fluctuations from year to year are not logically provided for by storage on account of the high depreciation in wood-waste fuel piles when stored for long periods. Hog fuel will depreciate from 35 to 40 per cent in fuel value when stored over a twelve months' period. This depreciation is occasioned by the volatiles being driven off, caused by heating in the fuel pile.

Experiments have been made to eliminate part of the moisture in the fuel before it reaches the furnace by utilizing the stack gases, but so far no successful method has been developed, owing principally to driving off part of the volatiles along with the moisture.

Sturdy Conveyors Needed for Handling

Contrary to what would be the belief of a casual observer, apparatus and plant equipment for handling hog fuel should be built with a mechanical strength just as great as, if not greater than, used for coal-fired plants.

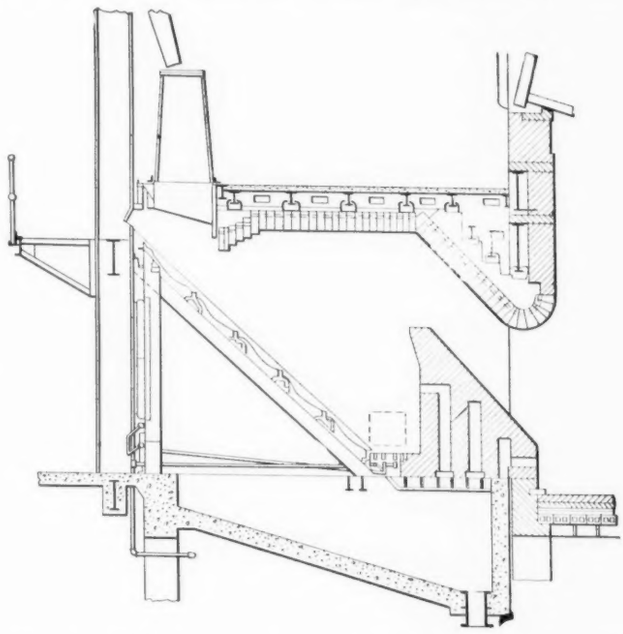


Fig. 2—Sloping-grate furnace gives good results with small boilers supplied with uniform grade of fuel

Forty per cent moisture gives the fuel more weight than seems apparent. Also, it is almost impossible to receive fuel continuously from any mill without at times having therein sticks and pieces of timber that jam conveyors, with the attendant excessive strains on equipment.

No attempt has been made in this article to cover the apparatus employed for handling hog fuel, but in conclusion it would be well to caution prospective users to investigate thoroughly methods used for handling the fuel before starting to build their plant, as many things are to be learned that cannot be figured out on paper.

Failures of Boiler Tubes Traceable to Segregated Metal*

RAPID steaming has raised important questions relating to boiler-making materials. While many valuable observations have been made on the treatment of feed water, less appears to have been done to improve the steel vessels in which the treated feed water is converted into steam. The general specification of tubes, for instance, stipulates an average chemical composition and certain mechanical properties, but it passes over the uniform distribution of the chemical elements, which is likely to be fundamentally important if the electrolytic theory of corrosion is reasonably correct.

The chemical composition of material machined from the inner and outer zones of steel tubes of badly segregated metal is given below:

	Inner Zone, Per Cent	Outer Zone, Per Cent
Carbon	0.11	0.06
Silicon	traces	traces
Manganese	0.43	0.40
Sulphur	0.085	0.030
Phosphorus	0.030	0.020

In order to determine the extent to which pitting and general corrosion in tubes could be ascribed to segregated ingot material, the following experiments were made under closely watched service conditions: Two 12-ft. lengths of 1½-in. solid drawn tube were selected, one segregated on the inside and the other free from segregations. These were arc-welded into one length and coiled to form a superheater. The coiled tube was placed in a boiler of 200 lb. working pressure and used as a superheater under normal conditions. The average steam temperature was between 600 and 700 degrees.

After about twelve months' use perforations appeared in the segregated length, so the coil was removed and different lengths of the two joined tubes were split open. The unsegregated tube was sound and not much the worse for wear, whereas the segregated tube was badly corroded and perforated. The scale removed from the interior of the segregated tube contained 0.19 per cent sulphur.

A second coil made from a single tube known to be free from segregations was in use at the same time under the same conditions. This, when dismantled after a similar period of service, was quite sound except for a few isolated and comparatively slight pittings.

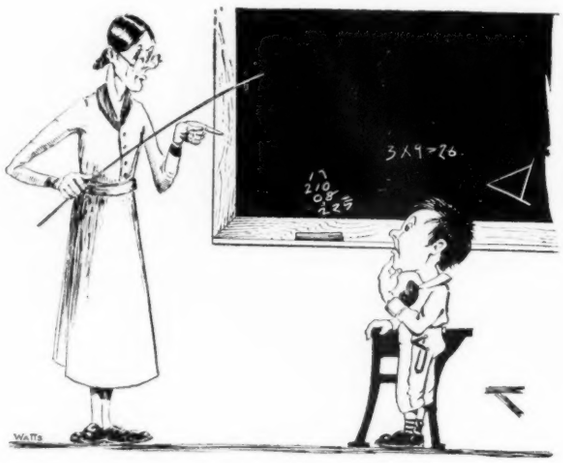
Practical experience indicates that coils always fail in some segregated portion, and where it has been possible to get positive evidence from service failures the trouble could usually be traced to segregated steel. The corrosion is not limited to the wet steam portion of the coil, nor to the part nearer to the fire.

Having concluded that tubes frequently failed from this cause, attempts were made to buy tubes free from segregations. This was, however, found to be exceedingly difficult. Tubes made from special Swedish billets were not reliable. The difficulty was overcome by purchasing an ingot of steel made with all the care devoted to the making of high-grade alloy steel ingots. Tubes made from this ingot were found to be free from segregations and the metal was also notably free from slag. The composition of this steel is similar to that given in the usual specification for boiler tubes except that the silicon is higher. This might be expected in acid steel, and it may have been helpful in making a sound steel.

The results of using such tubes have been most gratifying. Laboratory tests have been carried out over a long period and no failures have been recorded.

The production of perfectly sound and non-segregated steel entails, however, so wide a departure from ordinary steel production that the cost becomes high. The desirability of sound steel for boiler tubes cannot be denied, and it is a problem to be faced by the steel maker how to produce a better quality of steel, more suited to modern requirements of high pressure and superheat, without a considerable increase in cost.

*Abstract by James Silberstein, metallurgical engineer, from a paper by Messrs. A. R. Woodvine and A. L. Roberts before the British Iron and Steel Institute, June 3 and 4, 1927.



What Do You Know?

By L. H. Morrison

The answers are on page 264

A SUBSCRIBER to *Power* has sent in ten questions so excellent and of so practical a character that they are here presented to the other readers for solution. Some may require a little thought.

Ques. 1—What central station was the first to install a mercury-vapor turbine?

Ques. 2—Can a Curtis-type turbine be started without starting the auxiliary oil pump? Why?

Ques. 3—Can a Westinghouse turbine be started without starting auxiliary oil pump? Why?

Ques. 4—What high-speed engine has a governor with two eccentrics?

Ques. 5—What type of valves are used on a Rollins steam engine?

Ques. 6—Is there any way of changing the point of cutoff on a cross-compound Corliss on the low-pressure side?

Ques. 7—What would cause a Corliss engine to speed with a load on and slow down with light load?

Ques. 8—What is an air injector and where used?

Ques. 9—What is a Kingsbury thrust? What is it used for on a steam turbine?

Ques. 10—With a locomotive of the three-cylinder compound type where is the third cylinder connecting rod connected to driving wheels?

ELECTRICAL
Operation and Maintenance

An Elevator-Door Operator That Splits Seconds

THE time required for an elevator to make a trip may be divided into two parts, the actual running time and the time the car is held at the landing to take on and discharge passengers. The first is dependent on rates of accelerating and retarding the car, rates of car speeds, skill of the operator to make good landing stops, etc. Getting the passengers on and off the car is influenced by the shape and size of the car, the size of the landing door opening and speed of door opening and closing.

The latter is of greater importance than is generally appreciated. After the car arrives at the landing, the more quickly the doors are opened the sooner the passengers can begin getting off or on the car. Snappy operating doors also have a psychological effect on the passengers and make them move more quickly. Therefore, quick-moving landing doors have a double effect of reducing the time the car is at the landings.

When the doors are closing, the time is limited to about 1½ sec.; that is, to a speed where a passenger will not be injured if hit by a moving door. When opening, the passenger hazard has not to be considered and the only limits are mechanical, such as the forces that the doors and operating equipment will stand. This feature of door operation is one that is being given a great deal of attention at the present time.

One of the latest developments is the new door-opening equipment of Frank A. Boedtcher, New York City, shown in Figs. 1 to 3. Instead of one operating bar, as has been previously used on elevator doors, in this equipment there are two bars, *B* and *B'*. The purpose of the two operating bars is to overcome the tendency that the single bar has to tip the doors and cause them to bind, and in some cases break the door hangers, particularly if they are opened at high speeds.

The doors shown in the figures are of the center opening two-speed type; that is, each door is made in two sections with one section arranged to move by the other. They are also arranged to be opened by an electric motor. The operating bars *B* and *B'* are connected to the wheels *W'* and *W''* respectively, and the two wheels are connected by a rod, so that the two move in unison. Wheel

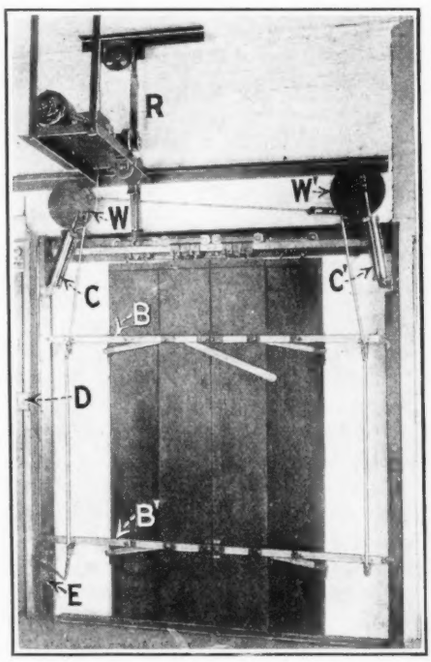


Fig. 1—Elevator doors in closed position

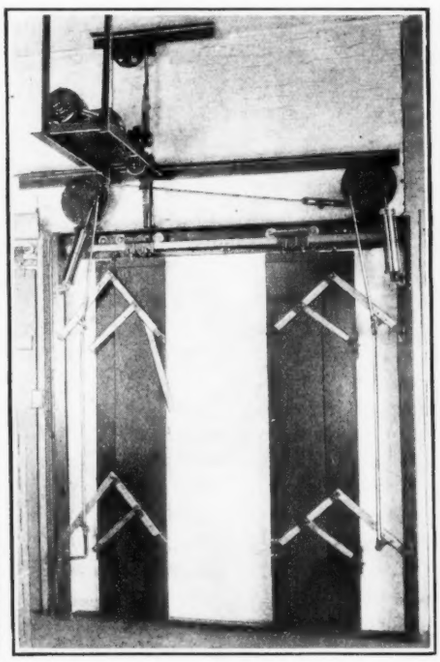


Fig. 2—Elevator doors in part-open position

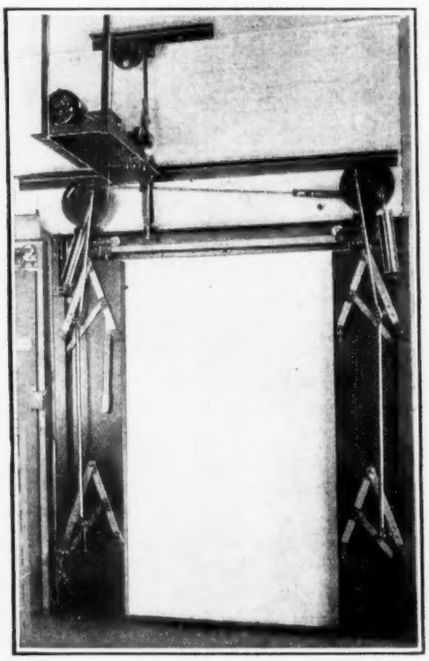


Fig. 3—Elevator doors in full-open position

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W is connected by a steel cable to a rack bar R. When the doors are to be operated, the rack bar is pulled into mesh with a gear on the operating machine. Then the machine starts and pulls the rack bar downward. This motion causes wheel W to turn in a counterclockwise direction, and wheel W' turns in a clockwise direction. The result of this action folds the operating bars as in Fig. 2, which shows the doors partly opened. It will be seen that the center sections of the doors have partly folded back on the rear sections and both sections have moved toward the open position.

In Fig. 3 the doors are shown in the full-open position. A comparison of Figs. 1 to 3 will indicate the

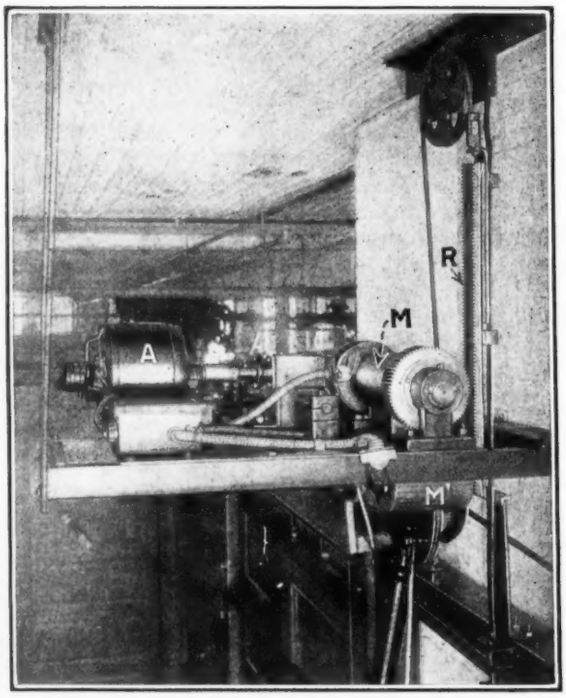

Fig. 4—Close-up view of the operating machine

action of the operating bars, when opening the doors. When the doors are released they are closed by a spring in the cylinders C, and the gravity action of the operating mechanism. These cylinders are filled with oil and have a piston arranged with suitable parts to retard the movement of the doors near the end of their travel in either direction. On account of the high speed at which the doors open, an effective means of retarding the motion of the door near the end of travel is very essential.

Doors weighing 300 lb. are being opened from a closed to a full open position in about three-quarters of a second. A number of features contribute to make this quick opening possible. First, the new operating equipment that is arranged to act near both ends of the doors prevents them from tipping and binding, no matter how much force may be applied by the operating equipment. The free-operating ball-bearing hangers also allow easy movement. These hangers were described in the Nov. 22, 1927, issue, page 800. Since the doors are in sections and open in both directions from the center, they have to move only one-half the distance, for the same opening, that would be required if the movement was all in one direction. Each door is in two sections, and one section folds back over the other, which results in one section moving one-half the distance of the other. This greatly reduces the power necessary to accelerate the doors, with a corresponding reduction in the strain on the operating mechanism. All the joints in the operating bars are fitted with bronze bushings so as to provide a good bearing area that gives free movement and allows replacement in case of wear without discarding the bars.

A close-up view of the operating machine is shown in Fig. 4. This machine is shown mounted above the doors in the shop. In practice it is mounted on top of the car. On the machine are two magnets M and M', which are energized when the door-operating switch, shown at D in Fig. 1, is closed. The magnetic pull of the gear wheel and magnet M' pulls the rack bar R into mesh with the gear. Then the motor A starts and turns the gear in a clockwise direction, which pulls the rack bar down and opens the doors as previously explained.

Near the full-open position of the doors the limit switch E, Fig. 1, opens and stops the motor. The magnet coils, M and M', remain energized and retain the rack bar in mesh with the gear and hold the doors open. When the door operating switch is opened, the rack is released and the doors are closed by the springs in the closing cylinders and the gravity action of the operating mechanism, as previously explained.

An Easily Made Tester for High-Voltage Circuits

By Maurice D. Smith

FATAL electric shock occasionally results from the case of a transformer or frame of electrical equipment coming in contact with a high-voltage circuit. This is generally due to defective bushings, wire insulation, or to oil, dirt and carbon particles collecting on an exposed surface and thus forming an electrical path from some live part to the frame or case. It is impossible to determine, by the eye, if the case is alive. Consequently, most employees of industrial plants and electric companies have a feeling that machines are perfectly insulated or the frames are grounded, and from the habit of touching the equipment whenever they desire. This may be done many times without accident, but coming in contact with 1,000 volts or more once may prove to be the cause of a fatal accident. In this article is described an instrument, devised by the superintendent of one company using 5,000 transformers of various sizes, for testing the transformer cases to determine if they are alive.

The instrument consists of a neon-gas-filled tube $\frac{3}{16}$ in. in diameter and $4\frac{1}{2}$ in. long, Fig. 1. A brass ferrule on each end of a glass tube is connected to two electrodes

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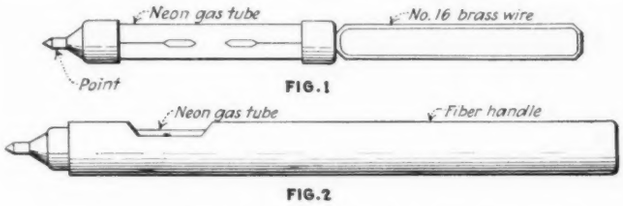
in the gas-filled chamber. The glass tube allows inspection of the electrodes to determine when they glow. To one end of the tube is soldered a metal point as shown in the figure. To the other a No. 16 brass wire 4½ in. long is soldered and is looped as shown. The outfit is inclosed in a fiber tube 10 in. long and $\frac{1}{16}$ in. thick, Fig. 2. A slot 1½ in. long and ¼ in. deep is cut in the fiber tube directly over the electrodes to permit inspection. The instrument is now complete and ready for use.

When brought in contact with the high voltage the electrodes emit a pale rose-colored light. The nearer the hand is to the tube the more brilliant the glow. If the person holding the tube is wearing a rubber glove, the effect upon the glow is hardly noticeable. As an extra precaution, when working on circuits of 2,200 volts and higher, it is best to wear a rubber glove.

Results are most readily obtained upon a grounded system, but tests show that light will be emitted when the tester is brought into contact with one side of an ungrounded system. Some tubes have been found to glow on a grounded system as low as 400 volts, the average being between 800 and 1,000 volts. There is little difference in the brilliance between 800 and 1,500 volts. At 2,000 volts or more a very bright glow is obtained.

The following procedure should be used to obtain satisfactory results, as it has been found that occasionally a defective neon-gas-filled tube may be obtained. A firm grasp should be made on the fiber tube with the thumb about six inches from the point or exposed end of the tube. Then place the point on the insulation of a live primary wire and notice if the tube glows. If it does, then place the point against the case or frame to be tested, being sure that good contact is made, and again notice if the tube glows. If it does, the frame or case is alive and should not be touched with bare hands under any circumstances.

After the test is made on the case, the point of the tester should again be placed on the primary wire as a check to determine that the tube is functioning properly. This procedure should be followed regardless of whether



Figs. 1 and 2—Neon-gas tube high-voltage tester

a glow is obtained on touching the case or not, as a positive check is essential.

The instrument was designed primarily for use in testing transformer cases on 2,200- and 4,000-volt circuits, but there is no reason why its application cannot be extended to other equipment using such voltages and be used to determine if the high-voltage circuits are dead before working on them.

Many in the industry have been operating high-voltage equipment for years with little thought but what bushing and wire insulation are in as good condition as the day they were purchased. They may be, but with age there is a possibility that some piece of equipment has become defective and may be the cause of an accident. Also, if the frames have been grounded, it may be that the ground connections are defective.

The instrument shown is inexpensive, requires little time to construct, and is satisfactory for use on circuits up to 4,000 volts. For higher voltages the tube may be placed in a fiber case, as in Fig. 3, and arranged with a brass ferrule having a threaded stem to screw in the metal end of a switch stick. The tube is screwed into

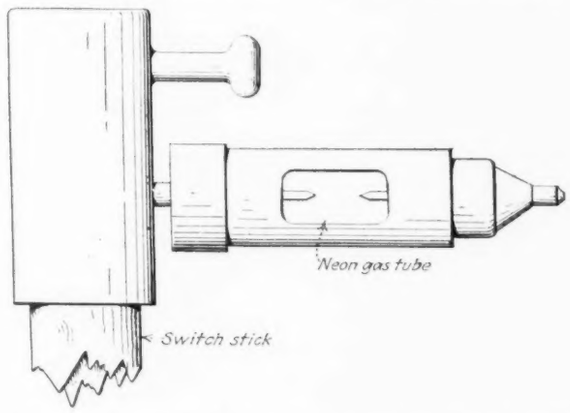


Fig. 3—Neon-gas tube tester on end of switch stick

the stick head only at such times as it is desired to test a circuit or piece of equipment to determine if it is alive. At all other times the tube is removed from the stick and does not interfere with the usual use of the latter. When used in the stick, as in Fig. 3, the tubes have been employed on circuits up to 66,000 volts. It should be kept in mind that the same precaution should be observed when using this tube that are taken when working on high-voltage circuits.

Unapproved Electrical Installations Are Dangerous

By A. J. Chistopher

THROUGHOUT this country, in homes as well as in industrial establishments, I have seen a vast amount of bad electrical wiring. If most of the surroundings were fireproof, one might shrug his shoulders, but when such highly combustible materials as cotton lint, inflammable oils or even materials of an explosive nature are present, the initiated at once sees the serious results that can easily take place.

It is fortunate that we have an association of underwriters who make initial inspection upon all new installations. Were it not for their strict regulations and requirements, what a mess the electrical installation in most shops would be! As it is, even with the present

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standards in force, many bad jobs of wiring exist. I believe that the cause for so much unapproved electrical work is neglect. All new work is usually inspected, for the insurance companies require the underwriters' approval before the owner is granted insurance. In many places the lighting companies are prohibited from giving electric service to a consumer without a permit from the inspectors. After the installation is approved, a certificate and permit to supply service are issued. The certificate gives a brief outline of the premises to which it applies and notes the total outlets, motors, etc., that are in use. Any additions or alterations automatically void the certificate of approval.

Here is where the slip occurs. There are few installations that remain as originally made, and the additions are in many cases made by incompetent hands, while the work is seldom passed upon by inspectors. The poor manner in which the electrical systems of many factories and plants are maintained would suggest some form of periodical inspection. It is true that most establishments have a so-called electrical man, who may be only a millwright or a novice, which fact is often the reason why the installation is not kept in proper, approved repair at all times. In the elimination of fire risks and shutdown periods due to blown fuses which result from short circuits, it would pay any concern to employ a competent electrician to remedy all poor wiring, replace worn cords, and other defective parts.

Flexible cords are among the worst offenders in causing trouble. These may be in the form of drop lights, extensions and portables. They are frequently not repaired or replaced when worn, but are continued in use even when the bare wires protrude, sometimes tied full of knots for shortening purposes and not infrequently the thread-bare cords are fastened about metal machines. Splices that are not mechanically perfect—that is, loose and unsoldered—show that an inexperienced person has done the work. Such joints often become hot, draw arcs and interrupt service.

Sometimes those who should know better are responsible for bad electrical jobs. I recall an instance where the electrical engineer of a factory allowed his men to place No. 16 telephone wire in conduit to supply factory lights. This wire was used on the permanent job because there happened to be a large quantity of it on the place. Would-be economy of this type does not pay.

Methods of Bending Conduit

By Guy W. Kay

ALTHOUGH cutting and bending conduit is generally a fairly simple operation when the necessary equipment is available for doing the work, it will require a little more skill under unfavorable circumstances. Large conduits are difficult to bend unless a bending machine is available, but the smaller sizes can be bent and fitted by the use of a hickey.

In the absence of the hickey I have used a cast-iron "T" pipe fitting as indicated in the figure. The "T" should be the next size larger than the conduit being bent. The bending is done on the floor with the workman standing on the conduit and pulling on the lever screwed into the "T." The bending should be done in short steps and the hickey worked up along the bend at each step to prevent kinking the conduit or forming rough spots.

A wooden post with suitable holes through it and substantially supported, has also been used to good advantage for bending small-sized conduit.

Large conduit is difficult to bend without heating unless a machine is available. I have bent large conduit by first filling it with sand and then heating before applying the bending process. The objection to heating is that it destroys the coating on the inside of the conduit and this is difficult to replace. To smooth up the inside of the conduit, I have blown hot paraffin through it and on the outside use an insulating paint. Every precaution should be taken to insure that the inside of the conduit will not be rough and injure the insulation or the wires when they are installed.

Conduit bent with a "T" pipe fitting

There is nothing said in the National Electrical Code about heating conduit when it is bent, but the code does require that "all surfaces of the conduit tube, elbows, bends and similar fittings shall be suitably protected from corrosion." If conduit is installed in a place where it would be subjected to corrosive action, the inspector probably would object to the practice of heating the conduit to bend it, but in dry places and where 90-deg. elbows cannot be used, there might be no objection.

When cutting conduit, I first use the pipe cutters to make part of the cut, after which the cutting is completed with a hacksaw. This gives a good clean square cut without the heavy burr left on the inside of the conduit when all the cutting is done with pipe cutters. It is then easy to ream the end of the conduit so that there will be no rough edges to injure the wire. If a reamer is not available, a half-round file will serve the purpose.

REFRIGERATION
Equipment and Operation

Is Volumetric Efficiency Important?

By Thomas M. Gunn

THIS article shows the importance, from certain viewpoints, of the volumetric efficiency of ammonia compressors and its lack of importance from other viewpoints. The factors that influence volumetric efficiency are enumerated and explained. Each of these factors is also linked up with its influence on the operating factors of efficiency; namely, output of the machine in terms of refrigerating effect and input in terms of power.

BEFORE one discusses the volumetric efficiency of ammonia compressors, the term should be defined in order that there may be no misunderstanding. As a matter of fact there have been many definitions given by various authorities which were no doubt useful for the purpose then in hand, so there may be no objection to one's making his own definition for the purpose that seems most serviceable today.

Volumetric efficiency is the ratio of the actual volume of gas coming to the compressor through the suction pipe, to the volume of the piston displacement. Piston displacement is easily understood, as it is merely the volume swept by the piston in its compression strokes per revolution. In other words, piston displacement is the product of the following multiplication:

$$\underset{\text{(sq.in.)}}{\text{Piston area}} \times \underset{\text{(in.)}}{\text{stroke}} \times \underset{\text{(strokes per rev.)}}{\text{number of compression}}$$

The result is in cubic inches; divide this by 1,728 and it is converted to cubic feet, or we may use feet instead of inches in the original multiplication. This piston-displacement volume is greater than the volume of gas that comes in through the suction pipe owing to several reasons, which will be discussed later.

Let us now try to define what we mean when we speak of suction volume.

If we have a thermometer well fitted on the compressor suction pipe near the machine, and if we also have a pressure gage that indicates the correct pressure in the same pipe, then we have the data necessary for calculating the volume per pound of ammonia vapor as it passes that point. This is easily calculated by means of the tables and charts for ammonia that have been prepared by the Bureau of Standards. To ascertain by calculation the actual number of cubic feet of the gas passing through the suction pipe per revolution, it is necessary to learn the weight of ammonia circulated in the system during that time, which can be measured by a venturi meter or a weighing meter on the liquid line. The product of the weight circulated per revolution and the cubic feet per pound of ammonia vapor at the suction pressure gives us the actual volume of ammonia gas coming to the compressor through the suction pipe per revolution, which we may call "suction volume" for short. We can then define volumetric efficiency as the ratio of suction volume to piston displacement.

It should be noted that we can easily calculate the volume per pound if the suction gas is superheated. If, however, the suction gas is carrying with it a spray of liquid ammonia, the volume of suction gas is indeterminate, since the thermometer will show the same temperature irrespective of the amount of ammonia in the liquid condition. This condition will be spoken of as "wet compression," which is an exception to the more general case of superheat in the suction, often called "dry compression."

If volumetric efficiency were 100 per cent then the suction volume would be equal to the piston displacement. But it never is 100 per cent and there is always a difference between suction volume and piston displacement. A graphical representation of the difference is outlined in Fig. 1 along with the parts that make up this difference.

The first difference is one that shows on the indicator diagram taken from the compressor during operation, and is due to re-expansion of the gas left in the clearance space at the end of the compression and discharge stroke.

Wiredrawing in the suction valves chokes down the admission of the suction gas. The indicator diagram gives an indication of this loss also.

The third difference results from leakage past the discharge valves, piston rings and suction valves. This

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effect does not show on the indicator diagram; it may differ with the compressor and changes with wear and repairs.

The fourth factor is *heat slip*, which consists in the transfer of heat from the hot parts of the compressor to the cold gas as it enters, increasing its volume before compression begins, so that, in its expanded condition, a smaller quantity can enter the cylinder at each suction stroke than could otherwise.

The first and second factors can be illustrated on the indicator diagram, and may be studied by the aid of Fig. 2. Using a special indicator built for use with ammonia, an indicator diagram is taken as with a steam engine, not forgetting to strike the atmospheric pressure line. The original indicator diagram, slightly distorted for the purpose of illustration, is shown in full lines, in Fig. 1. The back-pressure gage is read and, knowing the scale of the indicator spring, a line is drawn parallel to the atmospheric line at a height to represent the back pressure. This line cuts the compression line at the point marked *B* and the re-expansion line at the point *F*.

Re-expansion of the gas in the clearance space is shown by the fact that the line from *E* to *F* is not vertical, the amount of re-expansion being shown by the horizontal distance *a*, Fig. 1.

If there were no wiredrawing in the suction valve, the entire suction line from *E* to *A* would coincide with the back-pressure line, unless we consider inertia of the gases, which is sometimes noticeable at high speeds. At the point *A* the suction valve has closed, but the volume

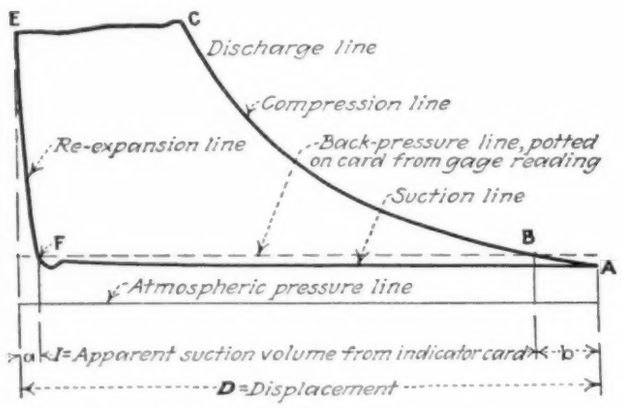


Fig. 1—An ammonia compressor diagram

of gas in the cylinder is misleading, because the pressure is below the back pressure. Compression begins and the pressure rises, reaching the back pressure at the point *B*. The indicator diagram shows the volume loss due to wiredrawing in the suction valves to be the horizontal distance *b*, Fig. 1.

There is a slight difference between the compression curve with dry compression and with wet compression, the latter being somewhat the flatter curve. In the re-expansion line this difference will be slight or great, depending on the condition of the gas in the clearance space. If there has been only a moderate amount of liquid taken in the cylinder with the gas, the contents of the clearance space will be somewhat superheated when re-expansion begins, and the curve will be close to that for dry compression. But if there has been much liquid injection or much liquid carried to the suction from the coils, there may be some liquid in the clearance space at the beginning of expansion. In this case the re-expansion line will be much longer and the re-expansion loss *a* in Fig. 1 will represent a greater portion of the

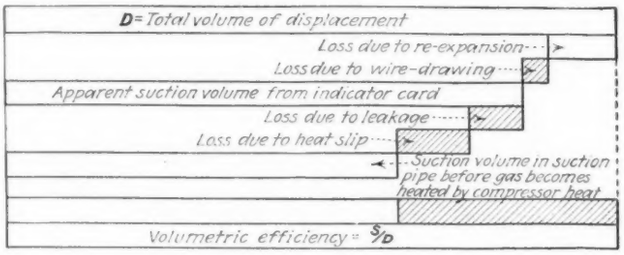

D=Total volume of displacement
Loss due to re-expansion
Loss due to wire-drawing
Apparent suction volume from indicator card
Loss due to leakage
Loss due to heat slip
Suction volume in suction pipe before gas becomes heated by compressor heat
Volumetric efficiency = S/D

Fig. 2—Where losses occur in the compressor

stroke. As already indicated, this would be unusual practice and not the rule.

It is well known that the leakage of valves or piston rings causes a compressor to run with abnormally hot discharge gas.

Leakage at any part of the compressor results in less weight of gas being delivered. The power consumption, however, is not decreased, and hence there is more work done on each pound of gas. Therefore, the rise of temperature, which is a measure of the amount of work done in the compression of each pound of gas, is greater as a consequence of the leakage.

The effect of leakage is to decrease the suction volume of the compressor, because part of the gas already compressed has leaked past the discharge valves, past the piston, or past the suction valve, and has prevented that volume of gas being drawn into the suction pipe. Furthermore, the volume of the gas that has leaked back is greater than it was originally because of the heating effect that has been explained.

Heat slip is a descriptive term that is clearer in meaning if we speak of a refrigerating machine as a heat pump, in which heat, to a greater or less extent, slips back from the warm to the cold side, much as leakage in a pump permits water to slip back.

It is seldom that an operating engineer guards as carefully against heating the suction gas as he guards against losses of refrigeration in the cold room or brine tank. It is, however, true that a heat loss in one place is as serious as in the other when it comes to the dollars expended. In each case, a B.t.u. lost is a B.t.u. of refrigeration made, but not available for use.

The place where this loss is especially noticeable is in the compressor itself. Here the hot discharge gases fill parts of the machine, while other parts form passages for the suction gas. If these two parts of the compressor are close together, there may be a rapid transfer of heat. In fact, there is always such heat transfer

REFRIGERATION *Equipment and Operation*

which means a loss in even the best designed compressors, but some are worse than others.

The direct effect of heat slip is to increase the volume of the gas that must be compressed, before it is compressed, and therefore to increase the work per pound of gas necessary for the process. This also decreases the capacity of the compressor, since it has a limited volumetric suction capacity at its full speed, and it can compress less pounds of hot gas of large unit volume, than it could of colder, more dense gas.

In modern compressor design this factor is receiving more attention than formerly and is an important subject in itself.

The effect of heat slip is to decrease volumetric efficiency by an amount that increases with the difference of temperature, since the greater the temperature difference the more rapid is the heat slip. This is one of the important reasons for the use of two-stage ammonia compressors where low temperatures are produced.

Where wet compression is employed, the effect of heat slip on volumetric efficiency is very marked. Liquid ammonia is capable of absorbing heat much more rapidly than the superheated vapor of ammonia. Hence, if the suction gas is charged with a mist of liquid, the spray may be vaporized to a large extent in passing over surfaces that receive heat from the compressed gas. At a temperature of 5 deg. F. the vapor occupies 333 times as much volume as the liquid. It requires only a slight evaporation in the suction to cause a considerable volume loss. On the other hand, the discharge temperatures are lower with wet compression, so that there is less "heat head" to produce heat slip.

The general conclusion as to the effect of wet compression on volumetric efficiency is that, where the compressor is designed to produce relatively little conduction of heat from the discharge to the suction, there will be little loss of volumetric efficiency through the practice of wet compression as compared with dry compression.

The statements found in literature on this subject are extremely divergent, some claiming that volumetric efficiency has no effect on the over-all efficiency of a refrigerating machine, while others assert that over-all efficiency is greatly reduced when volumetric efficiency is low. Each has a basis, but each statement, alone, is incomplete and misleading. It is necessary to consider separately the four causes: (1) Re-expansion of the gas in the clearance space; (2) wiredrawing in suction pipe and valve; (3) leakage past suction and discharge valves and piston rings; and (4) heat slip.

The operating factors in which we are mainly interested are the capacity of the machine to produce a maximum refrigerating effect and its relative efficiency, or power economy, represented by a low power consumption per ton of refrigerating effect.

Low volumetric efficiency, whatever its cause, decreases the capacity of a compressor for producing refrigeration. In designing a compressor or in selecting a new one, it is possible to make the cylinders large enough to produce the desired effect, if we but know what the actual volumetric efficiency will be. Where we have a machine installed and wish to secure maximum output, a knowledge of the factors influencing volumetric efficiency may help us to increase the output.

In relation to power economy the problem is more complex. Here the four causes act in different ways. The first cause of decreased volumetric efficiency, that is, re-expansion of gas in the clearance space, has no effect whatever on the horsepower per ton of refrigeration so long as the gas is superheated and does not contain liquid ammonia, since the expanding gas in the clearance space gives back to the piston the same amount of energy as the piston delivers to it during compression. This is not true if there is so much liquid present that there is still liquid in the clearance space when the compression stroke is completed. This has been explained.

The second and third causes, wiredrawing and leakage, are direct losses of power which are aggravated by the fact that they produce heating of the gas. The result is loss of refrigerating efficiency.

The same is true of the heat slip, which is much like the leakage loss, except that it is a leakage of heat instead of leakage of gas. The effect differs, however, when wet compression is practiced, and may then mean a still greater loss of power if the compressor is constructed with closely adjoining suction valves and discharge valves.

The first claim, that volumetric efficiency does not influence efficiency of refrigeration, is only a rough approximation to the facts when a compressor is constructed with tight and effective valves and piston rings and so designed as to prevent the loss of heat from the hot discharge to the cold suction gas. The effect of large clearance on refrigerating efficiency will be only slight, but will become noticeable if the ratio of compression is high.

Where low volumetric efficiency is the result of wiredrawing, leakage and heat slip, rather than large clearance, the power loss per unit of refrigeration is a matter of serious importance.

Finding Ammonia Leaks

Litmus paper is very useful in finding ammonia leaks. White litmus paper, which is most used, will turn pink when it comes in contact with ammonia fumes. Red litmus turns blue.

When any small leak occurs, even of gas under pressure, if a piece of water-soaked waste is placed over it, it will remove all trouble until the water is saturated. In case of a big leak, turn a water hose on it and drown it out; a large hose under water pressure should always be kept at hand.

If anyone is in danger of suffocation from ammonia fumes, breathing vinegar fumes will revive him. Drinking warm milk will relieve anyone suffering from partial suffocation from any gas.

If hydrochloric acid (muriatic acid) is placed in a bottle having an outlet glass tube passing through the cork and ending close to the bottom a second tube may be inserted through the cork so that it may be blown into. This drives some of the acid out in the form of a mist. If any ammonia is present white fumes will appear.

EDITORIALS

Submerged Combustion

ACCOUNTS have appeared from time to time of systems of submerged combustion. Gas and air in suitable proportions are thoroughly mixed on admission to a burner which, when in operation, is completely submerged under the liquid to be heated. The radiant heat of the issuing flame is readily absorbed by the surrounding fluid. Heat absorption is very effective, much heat can be generated in small volume, and the bubbling of the gaseous products of combustion through the liquid promotes good circulation. There is no heat transfer surface to suffer from scale deposits. A boiler or evaporator will be relatively small for a given output.

It will be apparent that the products of such a boiler could not be used in a condensing engine, for the large volume of uncondensable gases such as carbon dioxide and nitrogen would not permit a good vacuum to be maintained. The gas-steam mixture would function in a non-condensing engine provided there were no sulphur compounds in the products to start corrosion. In fact, it is claimed that such a mixture operates at high efficiency in a non-condensing engine.

The reason for this claim is that the presence of the gases makes the application of Dalton's Law of Partial Pressures necessary when considering expansion. If the engine exhausts at, say, sixteen pounds per square inch absolute, this pressure in the cylinder of the engine containing the mixture, is the sum of the partial pressure of the gases and the partial pressure of the steam vapor present. It will be obvious that the partial pressure of the steam present must be less than the exhaust pressure and that the steam has therefore had a greater range of expansion than would have been the case if no gas had been present, and it had expanded alone to sixteen pounds per square inch absolute.

Some years ago this scheme of air-steam mixtures to a steam engine was tested out at the University of Illinois, but nothing has been heard of it in recent years.

A submerged combustion process was developed by Brunler in Belgium some years ago, but has not been widely adopted. A new process of submerged combustion has recently been developed by Hammond in England and is engaging the attention of British engineers. However, it does not appear to have much of a field in power generation work owing to the need of compressors for the gas and air mixture and to careful adjustment needed by the mixtures.

Submerged combustion seems to have some advantages for evaporation of acids, alkalis and other solutions that are difficult to handle by ordinary means. Possibly it may find a place as an evaporating device in power plant work where large volumes of extremely impure water must be evaporated. It may be applicable to many industrial processes for heating or concentrating liquors.

High Temperature in the Power Plant

MUCH talk is going around in engineering circles these days on the use of higher steam temperatures than are now customary. One thousand degrees seems to be spoken of frequently, and it is reported that there are several plants in Europe operating with steam at this temperature.

The difficulty is to find materials for the construction of valves and piping, turbines and superheaters that will stand up satisfactorily under the severe conditions imposed by a steam temperature as high as this.

There is good reason for believing that such materials will shortly be available. The report of Mr. Malcolm's paper before the Metropolitan Section of the A.S.M.E., which appears on another page in this issue, indicates the lines along which this development is likely to progress.

Why should the power plant operator use higher steam temperature? Obviously, to generate power at lower cost. Of course, there are the secondary motives of securing the glory and distinction of pioneering, but after all this is an empty sort of glory, unless it is coupled with the reduction in the cost of power generated. It is no credit to an engineer to do a difficult thing if it is not worth doing. And so the whole thing comes back to dollars and cents. Fortunately for the engineer, it appears that there is a good chance of saving money this way.

The possibilities are especially promising for the industrial plant where steam is used for process heating after it has served its turn in the development of power. Raising the upper limit in the power generation service may increase the power available from a given steam flow and profoundly affect the combined cost of the two services. And doing this by increasing the initial steam temperature will also increase the dryness or superheat of the steam exhausted from the power generating equipment, and may thereby make it more useful for process work.

Slow-Speed Versus High-Speed Motors

MOTOR applications involve many considerations outside of selecting a machine of the correct size to drive the load. One of these is the speed at which the motor is to operate, and this affects other characteristics such as power factor and efficiency. So much stress has been placed on direct drive that many users of motors have come to accept this practice without question and proceed on the theory that unless the motor is connected directly to the load, sound engineering principles have been violated. Quite the opposite, however, may be true.

Where very slow-speed motors must be used to have a direct connection between the motor and the machine, it may be that a much more economical and satisfactory arrangement can be obtained by using a speed reducer and a high-speed motor. A slow-speed induction motor at best is an unsatisfactory machine for a number of reasons. Its dimensions and weight are unduly large for the work that it is to perform. Its cost is high. A motor operating at three hundred revolutions per minute will cost about twice as much as one operating at eighteen hundred. The full-load power factor of the high-speed motor will be around ninety per cent, that of slow-speed motor not much better than seventy-five. At half-load, the power factor values for these motors will be about eighty and fifty-five per cent respectively. This is important, since many motors operate for a large part of the time partly loaded.

If slow-speed induction motors are used, the power factor will be low, with its attendant undesirable effects on the power system. Where power is purchased, the low power factor of such motors may result in an increase in the power rates or, to avoid this, power-factor corrective equipment may have to be installed. The high-speed motor has an advantage of four or five points in efficiency, a considerable item in the power bill for a year. On the slow-speed motor the maintenance costs will in general be higher than for the high-speed machine.

Against the high-speed motor with the speed reducer must be considered the additional space required for the reducer, the cost of the reducer, its efficiency and maintenance. Additional space required for the drive will depend upon the type and the conditions under which it is used. Under certain arrangements the high-speed motor and reducer may require less useful space than the slow-speed motor. The cost of the reducer will vary from a small fraction of the difference in cost of the motors, to about equal to this difference. This, however, will be affected by the difference in speed between the slow- and the high-speed motors. The greater the difference in speed the more favorable the situation will be for the speed reducer.

The power loss in a high-grade speed reducer will be only two or three per cent and in large sizes somewhat less. Therefore the efficiency of the high-speed motor with a well-designed speed reducer compares favorably with the slow-speed motor directly connected. As to maintenance costs, these should not be any more for the high-speed motor and the speed reducer than for the slow-speed motor alone. If the equipment is properly installed and cared for, the maintenance costs should be low for either arrangement. There is no rule of thumb that can be applied to these problems; each must be decided on its merits if the most satisfactory drive is to be obtained.

Engineering Substitutions

READ the letter from John F. Hardecker on page 261 of this issue. It defines a real problem in many plants. The purchase of material that is not really needed is an obvious waste—not only in the cost of the material bought, but in the cost of handling the transaction through the purchasing and accounting departments, which may easily exceed the cost of small items. Time is wasted, too. And perhaps material is held in stock that will not be used for years. This is costly.

This is a problem that cannot be solved by the purchasing agent alone, nor by the storekeeper alone, nor by the engineer alone. They must work together. Why not try it?

Imagine the Savings!

IMAGINE what a difference it would make in the operating costs of some manufacturing plants if the process pumps were selected, maintained and operated with the same care and efficiency as the power plant pumps. A certain large chemical plant, for instance, has lost much operating time and has large maintenance bills because its process pumps are both unsuited to the work and operated poorly. Other plants let the repairs on process pumps go unmade until the trouble becomes so serious that a lengthy shutdown is necessary.

Of course, these conditions are not generally found, for most industries have been wise enough to put all pumps and pumping in charge of the power engineer. But, where that is not the case, the power engineer would often have a fight on his hands if he were to attempt to take this work over. So, naturally, he hesitates to start something that would do him no particular good.

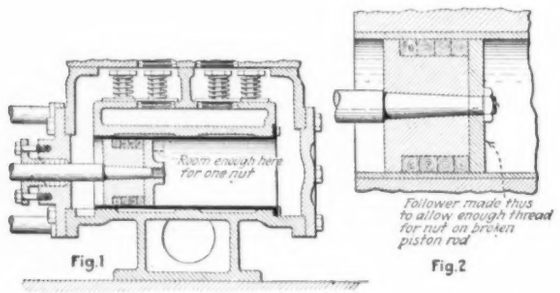
And the management is often reluctant to institute changes, especially when they think things have been running well enough. But, if all managements could be brought in some way to see that pumps and pumping are best cared for by the power engineer, imagine the savings that could be made!

IDEAS *from* PRACTICAL MEN

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Emergency Boiler-Feed Pump Repair

A PISTON rod in a boiler-feed pump broke off in the thread so close to the water piston follower that there was not enough thread left outside of the follower plate to get a nut on. Upon removal of the plate it was found that there was still enough thread on the rod to



Regular follower plate replaced by thin one to allow using remaining threads on broken rod

accommodate one nut if a thinner follower were used.

After some consideration it was decided that it would be much quicker to make a thin follower than to take the old rod out, make a new one and install it. Accordingly, a thin follower was made and installed as shown in the sketch at Fig. 2. P. EMERSON.

Topeka, Kan.

Building a Foundation Under a Brick Chimney in Sections

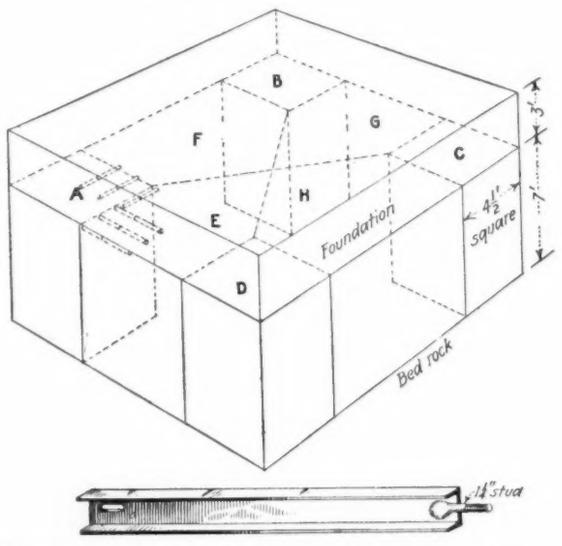
THE following article tells how a smokestack was saved from destruction after it was virtually wrecked by excavating close to the base without taking precaution to support the stack. The stack was 116 ft. high above the foundation and 68 in. inside diameter. The main column is of radial brick, and the base, which is 11 ft. square by 20 ft. high, is of vitrified brick. The foundation is 14 ft. square and 3 ft. thick, set in good solid clay.

About one year after this stack was built, it became necessary to enlarge the engine room to make room for more machinery. The management at this time decided on a basement 6 ft. 6 in. deep in the new room, and this took in the space around the stack, which left the stack standing on a pillar of clay 42 in. high above the basement floor. In a short time this pillar of clay began to crack and the base of the stack to show signs of distress due to uneven strains on the foundation.

About this time the plant changed hands, and the condition of the stack was put before the owners, who promptly decided that something must be done to save the property.

The first move was to reinforce the square brick base with bands made from four pieces of 6-in. extra heavy channels as shown in the illustration, each set being placed 4 ft. apart. On one end of each channel we welded a $1\frac{1}{4}$-in. stud, and on the other end we cut an eye and reinforced it to give it strength. Each set of channels, when drawn up, constituted a powerful clamp.

We next tackled the foundation, and, as this was a dangerous undertaking, procured the services of two experienced miners. By drilling holes we found that bedrock was within ten feet of the surface, so we decided to go to rock with the new foundation. We took one corner as at *A* at a time, going under the base and down to the rock, which constituted a column $4\frac{1}{2}$ ft. square and approximately 7 ft. deep. On the two inner sides we drove into the clay reinforcing steel, as indicated in the corner section *A*, leaving it protruding into the excavation we had dug, so that it would tie the next column



Shows how new foundation was built in sections and channel used to reinforce base of stack

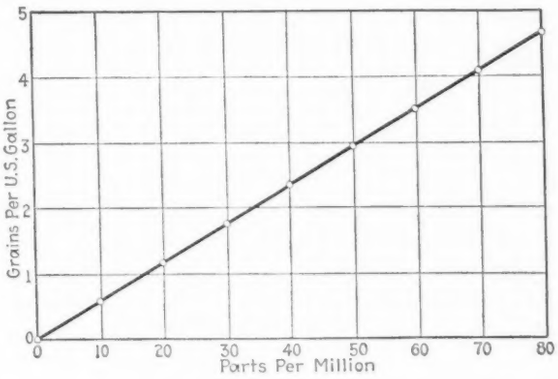
together, making one solid block when finished. The first column *A* was allowed to set before further excavation was made. When the corner was thoroughly set we proceeded with the opposite corner *C*, and when the four corners *A*, *B*, *C*, *D* were in, we built the center column in four sections as *E*, *F*, *G*, *H*, in the same way. When the work was finished, we had a solidly tied block of concrete under the stack. W. J. LAPWORTH.

Pittsburg, Kan.

Parts per Million vs. Grains per Gallon

IN WATER treatment and analyses different plants use various units in expressing contents of the water. The two most common units are "grains per gallon" and "parts per million." Besides, there are special terms used, such as "degrees," "per cent," and others.

To a novice this is confusing. For the conversion of



Curve shows relationship between grains per gallon and parts per million

"parts per million" to "grains per gallon" and vice versa, the attached curve is suggested, as a quick and simple means.

This curve is based upon the relationship:
1 grain per gallon is equivalent to 17.3 parts per million
1 part per million is equivalent to 0.0583 grain per gallon.

This ratio holds regardless of what constituent or property is under consideration, such as acidity, alkalinity, sulphates, carbonates, hardness, etc., as these terms relate to some common base. Hence, the curve is good for any such conversion. C. W. STEVENS.

Cleveland, Ohio.

Engineering Substitutions

AS BILL SMITH was heading homeward in his car, he chanced to spot his friend and fellow chief draftsman, Jack Brown, slowly walking along the street, obviously in deep thought. Responding to his hail, Jack climbed aboard and in due course related his difficulty.

"Bill," he said, "I find that the way we are handling our material and parts situation, often finds our purchasing department buying material or parts when we actually have in store something which would really serve the purpose just as well and which, unless it is used in just some such way, will ultimately be sold for scrap. Of course our purchasing department does the obvious and checks stores before purchasing, but the difficulty lies in the fact that the personnel that does this checking, can check only for material exactly as specified or something that practice may have established as an acceptable substitute. It often happens, too, that similar parts owing to being obtained from widely divergent sources, may bear totally dissimilar names, and so the feasibility of substituting one for the other is not easily recognized."

"Yes," agreed Bill, "we at one time had somewhat the same difficulty, but we've solved it rather easily, I believe. All our purchase requests must pass through the engineering department for final visé, and we have assigned to this duty one of our design draftsman who has been with our organization a long time. With the background he has of the 'reason for' our specifying certain materials or parts and his ever-growing knowledge of what we have in stores, he is often in a position to originate and approve a substitution that eliminates or reduces our purchases. Yes, the money he can save in the course of a year is considerable in view of the fact that it takes but a small part of his day's activity to do it."

Philadelphia, Pa. J. F. HARDECKER.

Making a Single-Connection Lubricator Work Satisfactorily

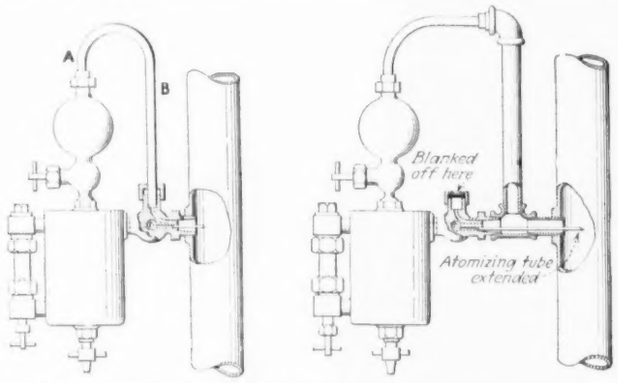
THE illustration, Fig. 1, shows a common form of single-connection hydrostatic lubricator, as applied to small steam engines and pumps.

It has been my experience that a lubricator of this type is always a source of trouble. It will feed the oil properly when first started, but soon slows down and stops until it is blown out and started over again.

Recently, I had occasion to investigate the cause of this unsatisfactory operation, and observations showed that when the lubricator stopped feeding, it seemed to be in a balanced condition, whereas it should have an unbalanced head of water in the condensation reservoir and vertical tube *A*, which forces the oil through the sight-feed nozzle.

A little experimenting showed that the cause of this balanced condition was that the drop leg of the condenser tube *B* was filled with water as well as the section *A*, instead of being filled with steam.

Having studied physics to some extent, I concluded that the water was held in the small-bore tube due to the



Figs. 1 and 2—Original and improved connection to lubricator

surface tension of the liquid, which was sufficiently strong to prevent steam getting into the tube to break the water column.

This line of reasoning suggested a remedy, and the lubricator was reconnected as shown in Fig. 2, ½-in. pipe and fittings being used. The atomizing tube was also extended to reach farther into the steam pipe. Since this change was made, the lubricator has operated satisfactorily. THOMAS C. PORTEOUS.

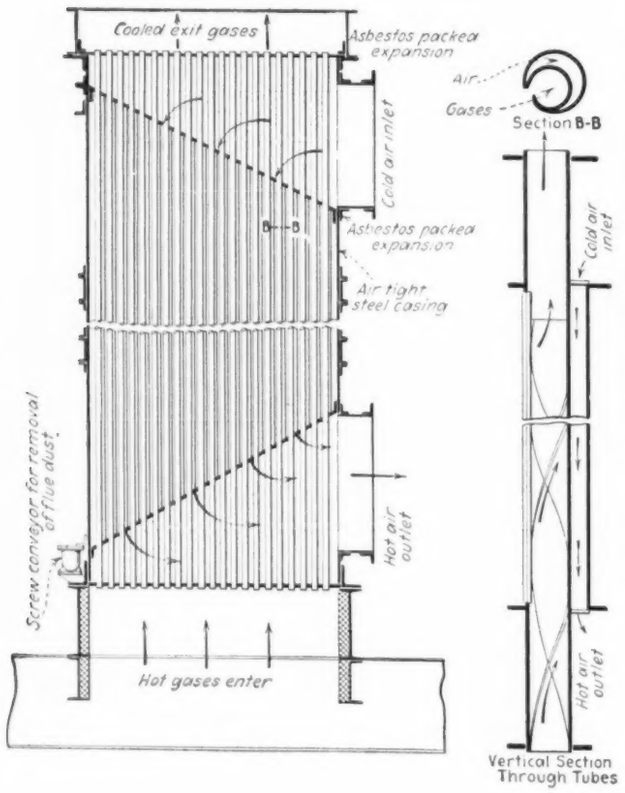
Michel, B. C., Canada.

COMMENTS *from* READERS

Catching and Utilizing Powdered Coal Ash

SOME TIME ago the statement appeared in *Power* that "The trend of the times is toward more rigid control of industry with respect to atmospheric pollution. In large cities there is a growing tendency to enforce smoke ordinances."

It would appear, however, from more recent comment



Cross-section of heater and tube, showing twisted strip in tube and method of removing ash particles from the gases

in *Power* and from various items in the daily papers, that the matter is being treated as a baffling problem.

The writer views this from a different angle, since anthracite and powdered bituminous coal are smokeless fuels, and when fired in proper furnaces and introduced into the combustion chambers in the right manner, there will not be any smoke or acidity in gases, although there will be the objectionable dust.

It is obvious, therefore, that the most common fuels are available for city purposes and that it is only necessary to extract the dust to make these fuels usable.

There are types of dust catchers now on the market that serve the purpose mentioned, some of which are simple and inexpensive apparatus.

The writer proposes an air preheater and dust extractor shown in vertical and horizontal cross-section, as indicative of an effort toward solving this problem.

The equipment is designed to remove most of the dust and heat from the waste gases of pulverized fuel and anthracite coal-fired furnaces, after which the gases may be washed, thereby condensing the acids if any should exist, and removing the finest particles of dust. The saving in power with an induced-draft fan handling such cooled gases would pay for the pumping of water to wash the gas.

The equipment has unique characteristics, being of the tubular counterflow type, with twisted metal strips within the tubes to cause the gases to rotate ejecting dust and increasing the heat absorption of the tube approximately 30 per cent.

The heater shown in vertical cross-section is arranged for the gases as they leave the boiler to pass in the bottom and continue through the scroll tubes to the top outlet of the heater, while the cold air enters one side at the top, passes downward over the outside of the scroll tube, within a confined air passage formed by the outer tube and is discharged from the side at the bottom. The scroll tubes form a direct passage for the chimney gases, with a minimum friction or draft loss.

The twisted metal strips cause a rotating motion to the gases, ejecting ash particles through the opening in the side of the tube. The gases scrub the inner wall of the tube and increase the heat absorption.

The ash thus ejected within the air tight casing falls to the inclined plate and is removed by a steam ejector or screw conveyor.

The illustration shows a vertical counterflow type, although the apparatus can be made for horizontal applications. Both are made in five sections, 5 ft. high by 5 ft. wide by 2 ft. 6 in. and are placed one above the other to meet the desired temperature of air preheat, and placed side by side for the required volume.

The apparatus can be protected against corrosion by coating the tubes with lead for marine work, or for corrosive gases where the temperature is not excessive, while copper bearing metal may be used for this purpose.

High-temperature air preheaters may be constructed of 15 per cent chrome steel for temperatures up to 1,400 deg.; with 30 per cent chromium they would be suitable for temperatures up to 2,100 deg. F. Chrome steel, while expensive, may be found economical where it is necessary to reduce the chimney gases below the dew point or in cases where the gases enter the heater at an extremely high temperature.

All ash removed from the furnace or ash hopper can be transported to another furnace, when it can be liquefied and drawn off into molds in various shapes for

building blocks, as for frame building foundations, reinforced beams or blocks for retaining walls.

This proposed furnace from which slag can be drawn off and cast into blocks for the purposes mentioned, has been in use since 1916. It has a high-temperature chamber, gases leaving through a water-cooled throat leading to a boiler, the latter having a thermal efficiency of about 70 per cent. J. GOULD COUTANT.

New York City.

* * * *

High Boiler Efficiencies

REFERRING to the observations of Henry James in the June 28, 1927, issue, we agree with his attitude toward high boiler efficiencies where these efficiencies are based on the pure guesswork or opinion of enthusiastic engineers. However, when efficiencies are arrived at through the use of adequate instruments and records, they must be accepted.

It would appear from Mr. James' little story regarding the plant with an exit-gas temperature of 400 deg., that he also has taken something for granted. Aside from the ideas concerning baffle walls of the unknown engineer, there are two possible reasons why the temperature indicator or recorder went from 400 to 580 deg. F., after the damper of the dead boiler was closed. The first is that the temperature element was not in the proper location. If it was in the breeching, it would be affected by the damper on the dead boiler, but would not be a true indication of the exit gas from the boiler in operation. This temperature element, to be properly placed, should be in the center of the flow of gas in the last pass of the boiler on the boiler side of the damper. If the temperature element is in this position, it would indicate the temperature of the gas from this particular boiler.

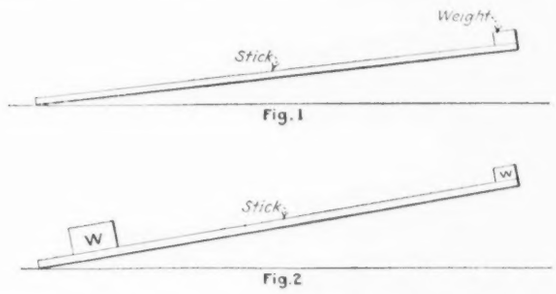
The second cause for the increase in temperature with the temperature element in the proper location would be the increase in draft and velocity of the gases through the boiler in operation, which would be caused by closing the damper in the dead boiler. This increase in draft would cause a larger amount of gas and possibly excess air to pass through the boiler in operation. This greater volume of gas passing through the boiler would increase the velocity of the gas and prevent the boiler from absorbing as much heat as before. It would be interesting to know what the CO_2, draft and flow-meter readings were before and after the damper on the dead boiler was closed. The temperature instrument, if properly installed, indicates an increase of 180 deg., but why jump to the conclusion that the new baffling is the cause of the increased temperature? The other instruments would help to a better understanding as to the cause of the increased temperature. It is possible that with the damper on the dead boiler open, the draft is cut to the point where operation is efficient. With the damper on the dead boiler closed the same result is possible by cutting the damper on the boiler in operation. No, I do not consider the engineer friend a poor fish. If his thermometer is properly installed and he finds that the flue-gas temperature is lower when he opens the damper on the dead boiler, he should keep it open. He may not have the other necessary instruments to tell him why the temperature drops but he is using good judgment. A. BITTNER.

New York City.

Why Brick Chimneys Fall As They Do

IN THE Dec. 20, 1927, issue, an interesting photograph of a falling chimney was published. While it is perhaps of no great importance, still it is interesting, and I wonder whether other engineers agree with me as to why the chimney broke as it did and fell as it did.

In the photograph only one break is shown—apparently about halfway up the chimney—and the fracture appears to be a distinct shear, similar to those obtained



Figs. 1 and 2—The high end of the stick tends to fall more rapidly than the weight

under a testing machine. The plane of shear makes an angle of about 45 deg. with the axis of the chimney.

My opinion is that at that plane of fracture a combined tension and shear existed for the following reasons:

If the entire chimney made no contact with the ground whatever and fell "out of the clear sky," it probably would not have broken at all before striking the ground. The velocity of the bottom would be the same as that of the top. There would be no bending moment. The adhesion of the mortar would be sufficient to hold the bricks together. There would be no tension or compression except that due to the air pressure.

Take a long stick, rest one end on the floor, as in Fig. 1, and hold the other end up, placing any weight on the high end. A coin will serve as a weight. Let the stick drop. Observe closely, and it will be found that the high end of the stick will fall more rapidly than the weight. A gap will invariably form between the stick and the weight, all of which may seem to defy the laws of gravitation.

The reason for this is that the particles of mass in the stick close to the contact end cannot fall as rapidly as the gravity laws would have them fall. Therefore they exert force on the particles farther out. The result is that the total forces acting on the particles at the tip of the stick are considerably greater than their weight alone, therefore the end of the stick falls more rapidly than the free weight.

To make this clearer, consider Fig. 2, where a heavy weight W is placed close to the contact end. The stick will fall much more rapidly, leaving a decided gap between the high end of the stick and the smaller weight w. The reason is obvious.

This, I believe, makes it plain why chimneys fall as they do. I have never seen a chimney fall, but I have seen photographs from time to time, and they always fall in the same way—concave upward. A "bend" occurs in the chimney, which, I believe, is due largely to the forces that I have tried to describe and illustrate here.

It is true that while the chimney is in its vertical and nearly vertical position as shown in the photograph, there are severe compression forces. The tensile stresses do not begin to act immediately. But as soon as they do begin to act, there is no doubt that they are partly the cause of the breaking up of the chimney first into two parts, and later into more parts. Although in the design of brick chimneys designers are careful to avoid tensile stresses, mortar nevertheless possesses some tensile strength. At least the mortar adheres well enough to alter the manner of falling of the chimney.

Reinforced concrete chimneys and steel chimneys usually fall in one piece.

If motion pictures of the fall were taken, it would be educational to see the action of the pieces all the way down. I read with especial interest the last sentence in the description, namely: "In falling it broke in three places and measured 265 ft. on the ground, having shortened 100 ft. in its fall." If there had been no mortar in the chimney, it would have shortened still more.

Newark, N. J. W. F. SCHAPHORST.

* * * *

Just Getting Along

THE Foreword in the Dec. 13, 1927, issue, "Just Getting Along," reveals still further the spirit of taking the bull by the horns instead of camouflaging and "calling in the Yes Chorus."

While recognizing, however, the necessary limits of paragraphs, I should like to have found the editor looking beyond the conception, long proclaimed, that there is lots of room at the top. The industrial pictures projected in the Foreword support the growing conviction that the "tops" are growing less.

Efficient as was the German autocracy, we believe that the more costly democracy comes closer to satisfying human desires. Must not, then, some of our aggregating capital for the benefit of the inside 7 per cent of the population (according to Professor Fisher's figures), some of our vaunted business efficiency, go by the board in favor of something more human? "Let us remember that all movement is not progress unless it tends to happiness." ROBERTSON MATTHEWS.

Detroit, Mich.

* * * *

Aluminum Bronze Paint Used to Seal the Boiler Setting

I AM sending the following to be used in the columns of *Power* whenever available.

The practical letter in the Jan. 3 issue entitled "Waterglass as a Base for Paint," reminds me of an experience I had some years ago. Several boiler settings had been covered with airtight boiler-wall covering having an asphalt base. Several attempts to paint over this material had resulted in the asphalt burning through and causing the paint to turn a dirty brown color. As an experiment, a small space was selected and six or eight coats of a light gray paint was applied, but each coat soon turned brown.

Casting about for some sort of sealer or primer, I thought of waterglass, which I had once used with considerable success as a waterproofing for concrete. The boiler settings were given two coats of waterglass, and I believed I had solved the problem, but I soon found that the expansion and contraction due to firing the boilers caused the waterglass surface to crack so badly that the asphalt still worked through sufficiently to discolor the paint applied over it.

The trouble was finally overcome by following the advice of a paint salesman, who suggested that aluminum bronze be tried. Two coats of aluminum bronze, made up by mixing the powdered aluminum with bronzing liquid, not only sealed the asphalt, but the surface presented such a desirable appearance that no other paint was used, although it is possible to paint over an aluminum bronze surface with other paint if one so desires.

Norwalk, Cal. A. C. MCHUGH.

Answers to What Do You Know

The questions are on page 250

Ans. 1—Hartford Electric Light Company at the Dutch Point Station, Hartford, Conn.

Ans. 2—Yes. As the turbine slows down, the mechanism of the valve gear opens the valves in the steam chest to the starting position.

Ans. 3—No. As it has a hydraulic valve gear with oil operation, the auxiliary oil pump has to be started to operate the valve gear, for the valves are held closed until the oil pressure comes on.

Ans. 4—The Armington & Sims engines were built that way.

Ans. 5—Gridiron steam valves and Corliss exhaust valves.

Ans. 6—Yes. On some engines there is a screw wheel on the end of the cross-shaft from the high-pressure side to the low-pressure side of the valve gear.

Ans. 7—If a single-eccentric Corliss engine is operating with a maximum cutoff, a heavier load—that is, an increased torque at the belt wheel—would cause the speed to drop and cause the governor collar to drop lower, causing the valve cam to be shifted beyond the point where it will unlatch the valve, and the valve will follow the wristplate to its extreme throw and back without unlatching. This would give the engine more steam than needed to bring its speed back to normal and as a consequence the engine will speed up until the governor brings the cam into its cutoff position again. If the governor has considerable inertia, this speeding up may be noticeable.

Ans. 8—An air injector is used for removing the air from a condenser and is used on both jet and surface condensers.

Ans. 9—Kingsbury thrust bearings are arranged so that there is a wedge effect to the film of oil between the two thrust parts. They are largely used on the propeller shafts of steam vessels and on steam turbine shafts.

Ans. 10—The practice differs. The rod of the third cylinder may be connected to a crank forged in the center of the axle of the leading wheels or may be connected to the axle of the second pair of wheels, in which latter event the cylinder axis is set at an angle to permit the rod to clear the leading axle.

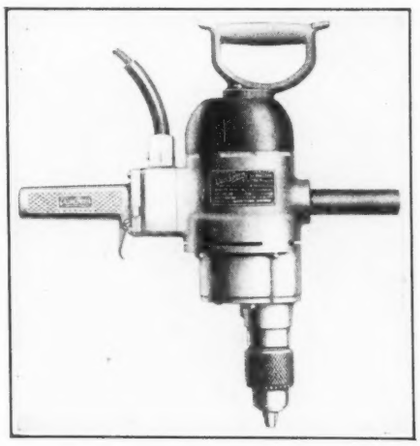
New and Improved EQUIPMENT

Van Dorn One-Half Inch Electric Drill

THE Van Dorn Electric Tool Company, Cleveland, Ohio, has recently added to its line of tools, the standard ½-in. electric drill shown in the illustration.

The motor operates on either alternating or direct current. It has a no-load speed of 540 r.p.m. and a full-load speed of 300 r.p.m. The armature is carried on ball bearings, and the thrust is also taken on ball bearings. Hardened alloy-steel gears are used in the speed reduction between the armature and the chuck.

The drill is equipped with a combination spade and breast-plate handle and



Van Dorn Electric Drill

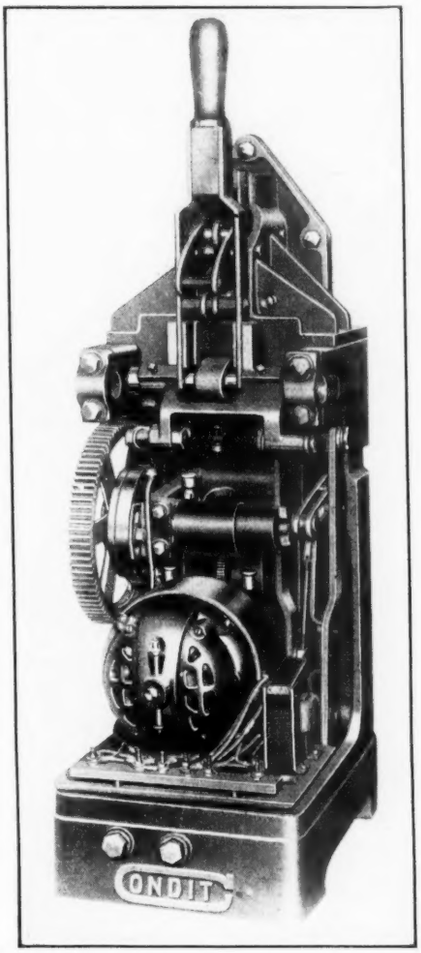
three-jaw screw-back chuck. It is furnished for use with 32,- 110-, 220-, and 250-volt circuits. The drilling capacity is ½-in. in steel. The weight is 14 lb., and the over-all length is 15⅜ inches.

High-Speed Circuit Breaker Operating Mechanism

THE mechanism for closing and opening of circuit breakers is an important factor in the successful rupturing capacity of the breaker, and a great deal of attention has been given to this feature.

A high-speed oil-circuit-breaker closing mechanism has recently been developed by the Conduit Electrical Manufacturing Corporation, Boston. It consists essentially of a combination of springs, mechanism and a motor through which stored energy is released for closure at will or automatically. The actuating spring is always under tension ready for closure, as the motor sets the spring after each closing operation.

Less than one-fourth second elapses between the energizing of the release coil and the closing of the breaker. After closing, from five to ten seconds is taken by the motor in storing energy in the spring for the next operation, depending on the size and type of



View of breaker-closing mechanism

breaker. Automatic reclosing may be obtained by using an external timing relay. The mechanism is well adapted to panel, panel-frame or wall mounting in substations or isolated switchhouses. It can be furnished arranged with automatic trip-free with one, two or three coils; transformer trip or two-coil series trip and can be operated from a 200-watt potential transformer. The mechanism is specially adapted to the operation of moderate capacity breakers for synchronizing purposes and for automatic change-over switching.

Morgan Replaceable Link for Chain-Grate Stokers

WITH a view to facilitating the replacement of broken links on certain types of chain-grate stokers, the replaceable link illustrated was developed by A. L. Morgan, 244 Percival Ave., Montreal, Canada.

The new link is of substantially the

Fig. 1—View of link with holding pins in position

same construction as the standard link furnished by the stoker manufacturer except that the bar holes are open at the bottom, to permit dropping the link into place without removing the bars or disturbing other links of the stoker.

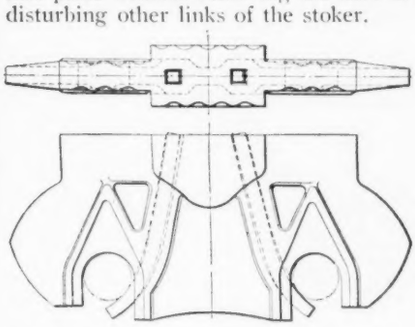


Fig. 2—Detail of replaceable link

The method of securing the link in place is rather novel. Two curved holes, as shown by the dotted lines in Fig. 2 are cored in the casting, and when the link is in place square pins are driven in and lock the link to the bars, as illustrated. If necessary to replace this link, the pins are driven clear through and the link can then be lifted out and a new one dropped in place.

"Biasbrix" for Furnace Wall Construction

THE refractory known as "Biasbrix," recently introduced by the General Refractories Company, Philadelphia, Pa., is designed to overcome the difficulty of making brick stay put and the tendency for walls to loosen up and joints to open, resulting in heat losses, slag penetration and eventual disintegration. As the name implies, "Biasbrix" are laid up on the bias, one brick overlapping and tying together

Wall construction of Biasbrix

three other bricks in self-locking construction.

Although different in shape it is claimed that "Biasbrix" can be laid as readily as the ordinary straight brick in any thickness of wall from 4½ to 27 in. or more, and are equally well adapted to large or small installations. They are particularly suited for hollow wall construction, where a strong bond is of importance.

Builders Iron Foundry Shunt Steam Meter

TO MEET the demand for a mechanical type of meter to measure the steam flowing through small pipe lines, the Builders Iron Foundry has brought out the shunt steam meter (Type KS) illustrated.

The meter is a complete unit in itself and is designed to be placed directly in the pipe line. Referring to the cross-section Fig. 2, as steam enters the meter, a portion of it is deflected upward through nozzles and rotates the small turbine mounted on the vertical shaft. This eliminates moving parts from the main line of flow. Near the lower end of this shaft is mounted the damping fan which revolves in a chamber filled with water formed by condensation, keeping the turbine speed low. The counter train at the lower part of the meter is driven by the turbine shaft through a permanent magnet, thus preventing the possibility of leakage of water into the counter chamber and avoiding stuffing-box friction. The counter dial, which is vertical, can be arranged to face in any desired direction. The meter is made in 2-, 3- and 4-in. sizes and for pressures from 3

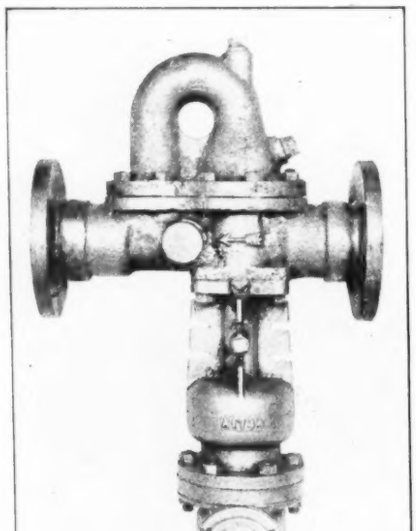


Fig. 1—Shunt steam meter

to 225 lb. gage. It is made with flanged ends only, companion flanges being furnished when desired.

The meters are calibrated to read correctly for the particular pressure specified by the customer. It is claimed by the manufacturer that in ordinary

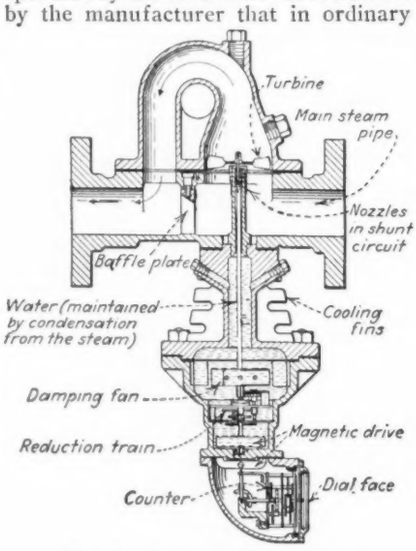


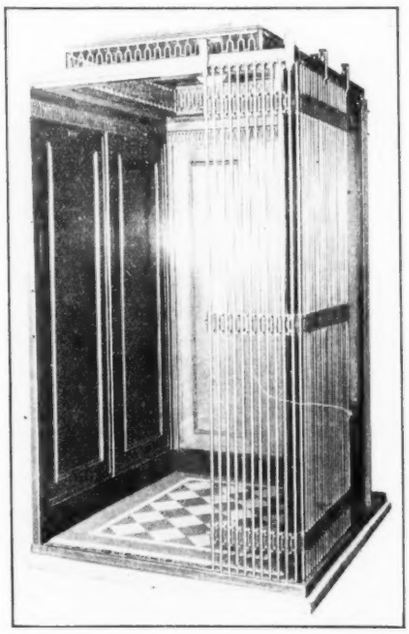
Fig. 2—Cross-section of meter

service, unless this pressure varies excessively, no correction will have to be made as ordinary pressure fluctuations will not alter the total reading over a reasonable period. Correction factors are furnished for pressure variations encountered in testing or in a temporary change of working conditions.

Safety-Type Elevator Gate

THE pantograph-type gate has been used so long on elevator cars that it has come to be accepted without question. Although it has served well and long, it has a serious accident hazard, especially if power operated. If a passenger or the operator happened to get their fingers between the gate bars when it was opening, they would be seriously injured. In crowded cars there is also the possibility of the passenger's clothing being caught in the gate.

To overcome these and other objections, the Otis Elevator Company, New York City, has developed and placed



Elevator car with gate partly open

on the market what is known as a safety-type car gate. This gate consists of round tubes linked near their ends and at the center. It runs in guides at its top and bottom ends and is supported on ball-bearing hangers. As shown in the figure, it is arranged to run around to the side of the car out of way of the exit. This design permits an opening equal to the width of the car. The tubes are placed with less than one inch space between them, so that they provide greater protection to the passengers than the pantograph gate.

Owing to its strong construction the safety gate is well adapted to power operation. For push-button elevators in private homes and apartment houses, where the elevator is operated by women and children, the gate gives them added protection by the closeness of the bars.

These gates are made with steel tubes and aluminum links, bronze plated and oxidized; solid bronze tubes with bronze aluminum links; with steel tubes and aluminum links lacquered to correspond in color with the car.

What Is the Limiting Temperature in Central-Station Operation?*

By V. T. Malcolm

THE author concludes that the design of equipment must be based on the strength of metals at operating temperatures, over long periods of time, and that other properties such as thermal expansion, thermal conductivity, chemical stability, resistance to wear and abrasion, etc., must receive greater attention than in present engineering practice. These latter factors will probably govern actual design, but the first and basic requisite is that of physical strength at the proposed temperature.

DURING the last several years considerable thought has been given to the use of increased temperatures in the operation of central stations, but as yet engineers have hesitated to design a station of this type because of the alleged inability of metals to withstand temperatures above 750 deg. F.

As the author sees the problem in this country, the temperature limit is a matter of opinion based on examination of available information on metals. The subject has many ramifications, and a perusal of its extensive literature discloses many inconsistencies and contradictions which are difficult to bring into agreement by any reasonable explanation, and which in some cases are so opposed to each other as to arouse suspicion regarding the accuracy of the investigation. To many, impressed by present difficulties, a temperature of 1,000 deg. F. for use in steam plants may appear high; but when dealing with ultimate limits, we are surely allowed to grant the possibility of advance, particularly in a direction in which so much progress has been recorded in the recent past. The same misgivings we have at present were obstacles not long ago when the limit was raised from 550 to 750 deg.

The foremost and probably one of the most important of the engineering problems awaiting solution is that of the strength and elasticity of metals at elevated temperatures. Broadly speaking, the solution of this problem would place us in a position to determine certain principles and the answers to many questions, particularly the cause of corrosion and the effects of temperature.

We know from experience that methods of test as applied to metals at normal temperatures are misleading when employed in high-temperature investigations, because of the softening effect produced at high temperatures. In precise testing it will be noted that the volume of steel does not remain constant but increases, and this disturbance tends to show that a molecular change takes place when the metal is strained as well as possible changes in the relation of certain microconstituents, which are brought about by changes in density in the metal.

We know that for every stress, no matter how small, there is a corresponding strain or deformation in the body acted upon, which strain increases as the stress is increased. The stress and corresponding strain are directly proportional up to a certain point, which is the limit of proportionality, below which, by removing the stress, the corresponding strain will disappear and the metal is said to be "elastic." When metal is deformed beyond the proportional elastic limit, it is said to be overstrained; this overstrain may be considered as a part of the total elastic deformation of the metal remaining after the external load has been removed, and when added to the permanent deformation due to plastic action will give the permanent deformation. These important characteristics, from which designs may be calculated, may be determined more or less readily.

When the same tests are applied at high temperatures, it is found that ordinary steels no longer possess the same elasticity, and as the temperature is increased the yield point loses definiteness and finally vanishes altogether. Furthermore, on carrying out the tests to destruction, fracture occurs at a much lower maximum stress than at normal temperature and is more readily accomplished if the test is carried out slowly than at a more rapid rate.

It has been proved that if a load applied at any particular high temperature is gradually reduced, a stress is reached at and below which no "creep" or "flow" is produced, no matter how long this stress is maintained. The term "flow" or "creep" must be used advisedly, because there is in most cases a slight "creep," not more than half of one per cent. Under continued loading at this critical stress this set becomes permanent and no further "creep" occurs.

Investigations have shown that there is a critical stress at each temperature, at which the metal may "creep," and that it continues to deform under continuously applied load; but in time this creep will drop to zero and continue there, while above this stress the metal will creep rapidly until final fracture.

Therefore it is the author's belief that at each temperature of the metal tested there is a stress which, if exceeded, will cause fracture, though equipment may give satisfactory service operating at this temperature with loads greater than the critical stress for many years.

In summing up the results of creep tests, three distinct types of stress may be noted:

1. A creep stress at which the flow of metal may be quite great;

2. A creep stress which shows a certain amount of deformation—up to 3 per cent;

3. A creep stress or critical stress at which no appreciable creep takes place.

The correct determination of the creep stresses is most useful in providing the engineer with data on which he may base his designs. The results shown by the creep test may appear very low, but they are the safer designing stresses.

Conclusions are that the design of equipment must be based upon the strength of metals at operating temperatures, over periods of long time, and that other properties such as thermal expansion, thermal conductivity and chemical stability must receive greater attention than in present engineering practice. These latter factors will probably govern actual design, but the first and basic requisite is that of physical strength at the proposed temperature.

Chemical Stability

Excellent physical properties at elevated temperatures, however, are not the only criteria to be used in selecting metals, as scaling and oxidation are decided factors. The real difficulty in connection with high-temperature work is the combining of the necessary physical properties with some particular chemical stability so as to have correct design for a complete working unit.

Problems of corrosion at high temperatures, while not so formidable as under ordinary conditions, are far more difficult to solve because of the greater

*Excerpts from paper presented at meeting of Metropolitan Section, A.S.M.E., New York, Jan. 30, 1928.

chemical affinity at elevated temperatures, or the disturbing of the chemical equilibrium due to operating difficulties. Only under ideal conditions can problems of oxidation be considered apart from the accelerating effects of other elements than oxygen. The presence of other gases or compounds increases the rate of oxidation, depending upon what metals or conditions are involved.

Therefore, on account of the field being so broad and because of other difficulties, the work of investigators should be that of narrowing down the field of alloys and indicating the trend of progress.

Thermal Expansion

When thermal-expansion stresses exceed the proportional limit of a metal, they produce certain deformed areas which are set for the highest operating temperature of the cycle and are likely to cause failure when the temperature returns to normal after a number of repeated cycles.

As an example, when steam or hot gases are admitted to pipe lines and all points are heated to a high temperature, the result is stretch or expansion in the stud bolts in the flanges. When the line is shut off, all parts cool, and if the stud bolts return to their original length as when first "drawn up" the joint will be tight; but if they have taken a permanent set due to expansion stresses (in combination with other stresses) beyond the proportional limit the bolts will be overstrained, and of course will not return to their original length, and the joint will leak. When joints leak they are again "drawn up," and this operation is repeated until finally the strains set up are so great that the bolts fail, the fracture being crystalline.

Wear and Abrasion

Hardness appreciably improves performance, but hardness itself is no certain criterion of the erosion resistance of various metals, as this depends to a great extent upon the structural composition, and extremely hard metal is unsuitable to resist shock on account of its brittleness. Hardened steels that have been tempered, while not so resistant, are far superior for severe service conditions on account of their toughness, and this toughness certainly is a factor that tends to resist erosion and wear.

Resistance to erosion does not, in general, increase directly with strength or hardness. Both hardness and toughness are important factors in determining the wearing qualities of a metal, because hardness increases resistance to penetration, scratching, and displacement of the metal, while toughness makes it difficult to tear off small particles of the metal, which particles, when torn off by rubbing or sliding action, constitute an abrasive of considerable effectiveness.

Therefore a metal which has a certain amount of hardness combined with good impact value, denoting toughness, is better suited to resist erosion and wear than one possessing only great hardness.

It has been found by experiment and also practice that when similar metals of the same hardness are rubbed together, they will not slide under pressure without "seizing" or "galling," especially at high temperatures, although no explanation of this phenomenon is yet available. This condition probably accounts for the fact that when stainless disks and seats of the same hardness have been used in valves, the faces of the disks have been scored or roughened and in a number of cases severe "galling" has taken place.

The author finds that by lowering the hardness by varying the heat treatment between seats and disk, "galling" may be reduced to a great extent, and in the steam plant this tendency to "gall" may be mitigated by making the seats of a ferrous alloy and the disk face of a nickel-copper alloy, because with this combination there is absolutely no tendency to "seize." As wear is more severe on the seat than on the face of a disk, the latter being out of the path of steam when a valve is fully opened, the more resistant metal should be used for seats.

It must be remembered that any hardness produced in steel by quenching and tempering will be lost in service if the tempering necessary to produce the required hardness has been carried out at a temperature below the operating temperature.

Discussion

Discussion on this paper was opened by W. M. Polakov, who cited experiences that are now being obtained in Europe with high temperatures. Few long-time tests have been made there, but plants are being built that are using temperatures as high as 1,100 deg. F. He felt that Malcolm's data are more valuable to industrial plants, where the advantages of high initial pressure and temperature are more promising, than to the central station.

G. A. Orrok referred to the conflict of authorities as to whether creep always exists or whether it exists only above a minimum stress and temperature limit and pointed out that equations for the modulus of elasticity disagree. Practically, it is probably best to consider that creep begins at a certain temperature and at a stress just below the proportional limit.

Creep limit curves (limit stress against temperature) obtained from English sources were shown to disagree with similar curves obtained in this country, the English curves showing a hump between about 650 and 750 deg., whereas the American curves had none. This he thought might be explained by the fact that all the English curves represented tests on higher-carbon steels. Curves from German sources were also shown, but only for higher temperatures. From this compilation of data Mr. Orrok has determined, for his own use, a curve for steel having a carbon content of 0.15 by taking a stress of about 11,000 to 14,000 lb. at 750 to 800 deg. and about 5,000 lb. at 1,100 deg. F.

In superheating steam to 1,100 deg. total temperature, the inside of the tube is hotter than the steam and the outside of the tube is still hotter, probably 125 to 150 deg. higher than the steam. This, he points out, brings the tube temperature close to the recalescence point, where little is known of the properties of the metal except that it becomes pasty and loses strength.

C. A. Spencer pointed out that the inconsistencies of test results act to make engineers cautious in going to higher temperatures, and that the central station is not the place for radical experiments.

John Lawrence expressed the opinion that central stations were having enough trouble with temperatures of 750 deg. and that the best materials for the present temperatures should be obtained before going to any higher temperatures. The troubles referred to were with steel tubes and not with valves, which in the larger sizes, he said, had given satisfactory performance.

He remarked that if all engineers would insist upon hot-water tests for valves and fittings, much would be learned. The inadequacy of cold-water tests was shown in the case of a shipment of fittings, 85 per cent of which were rejected when tested with hot water, although previously accepted on cold-water tests. The water for hot tests should be at least 250 deg. and 350 deg. if possible.

An interesting experience was related by G. K. Saurwein regarding an industrial plant that had been designed for 400 lb. pressure and a total temperature of 750 deg. When this plant was placed in operation, it was discovered that a steam temperature of over 950 deg. F. was being obtained. The plant was operated for about three days before it was shut down and the temperature conditions remedied. An examination of the turbine and of the pipe joint bolting showed that no damage had been done.

In closing the discussion, Mr. Malcolm observed that all the American creep stress curves that he had seen showed a hump between 650 and 750 deg. In this range the steel has maximum strength with minimum elongation and reduction of area; that is, the metal tends to be more brittle at these temperatures than at other temperatures. In this connection Mr. Malcolm expressed the opinion that in this range there is more likelihood of trouble than at higher temperatures.

Present tendency seems to be for the laboratory to frighten the engineer by too refined methods. As an example of this he pointed out that with a very sensitive extensometer the proportional limit of steel will be found to be very low. He expressed the opinion that steel is a non-elastic metal and in this connection agrees with Bailey, who regards actual behavior of metals as asymptotic to theory.

The importance of thermal conductivity in design was brought out by his remark that stainless steel takes three times as long to heat up as ordinary carbon steel.

NEWS *of the* FIELD

Power Inquiry Plan Approved

Senate Committee Adopts Walsh Resolution

THE Walsh resolution for an investigation of public utility power corporations has been ordered favorably reported to the Senate by the Senate Interstate Commerce Committee.

This resolution would authorize a committee of five members of the Senate to investigate the growth of the capital assets and capital liabilities of public utility corporations doing an interstate business and of holding corporations having the stock of two or more public utility corporations operating in different states.

The resolution includes an investigation of the relations that may exist between the power utilities and the holding companies for the purpose of determining what legislation, if any, should be enacted by Congress to correct any abuses that may exist in the organization or operation of such holding companies.

The committee would be further empowered to inquire to what extent such corporations through the expenditure of money or through publicity, have influenced public opinion regarding municipal or public ownership of the means by which power is generated and distributed.

One of the changes to the original resolution approved by the committee confined the proposed investigation of campaign expenditures by power corporations to those contributions made to elections involving the President of the United States, vice-president, members of the Senate and House of Representatives.

The unanimous approval of the Walsh resolution as amended came after a deadlock in the committee which failed to refer the proposed investigation of power utilities to the Federal Trade Commission.

Louvain Library to Be Dedicated in July

The new Louvain Library, destroyed by the Germans during the World War and restored by American benefactions, will be dedicated on July 4 of this year, according to present plans, says a statement by the Engineering Foundation, New York City. The Belgian Ambassador and Whitney Warren, of New York, the architect, have both assented to this date, the Foundation announced, and the sanction of the Louvain authorities is expected.

The Foundation is arranging for the presence of a delegation of American engineers at the dedicatory ceremonies. Under the auspices of the Foundation, a clock and carillon will be placed in the tower of the new Library building at a cost of $80,000, to be subscribed by members of the engineering profession in this country.

Up to Jan. 25, $32,300 had been contributed by 1,880 engineers in amounts of 25 cents to $5,000. Dr. Edward Dean Adams, engineer and financier, of 920 Fifth Ave., New York City, is chairman of the Foundation's committee in charge of the movement reports. The mechanical engineers lead in the amount of subscriptions, with the civil engineers second, the mining engineers third and the electrical engineers fourth. Associated societies have given $927, and $5,250 has been received from friends.

The clock and carillon, the gift of 56,000 American engineers, will be installed "In memory of the engineers of the United States of America who gave their lives in the service of their country and its allies in the Great War 1914-1918." Doctor Adams will head the United States engineering contingent at Louvain.

"There are 48 States in our Union," Doctor Adams says. "There will be 48 stars in the four dials of the clock on the tower of Louvain Library and 48 bells in the carillon."

Large Hydro-Electric Power Project for Madras

An exhaustive study of the Pykara hydro-electric project, Madras, has recently been undertaken by Mr. Howard, chief engineer for hydro-electric development to the Madras Government, India. It is proposed to avoid the construction of high dams and large reservoirs, which would not in any case be needed for some years, and modifications have been introduced into the previous designs for the power plant and transmission system.

The project contemplates the progressive development of small storage sites on the headwaters of the Pykara River and its tributaries, to fit in with the demand for power. This method will not, however, reduce the ultimate capacity of the scheme below that proposed in previous reports. On the contrary, it is expected that when the power is needed a maximum of 90,000 hp. will be available. This amount exceeds previous figures.

The site of the power plant is on the Singara Estate, near Masinigudi. The initial installation will consist of three 10,000-hp. units, which number will be increased to five when required. Later, the addition of two 20,000-hp. units is contemplated should power demand warrant it. After the water is used in the Pykara power plant, it will be possible to divert it by a canal into the Avarihilla River and use it again in another power plant, which could be constructed on the banks of the Moyar River. The head on this plant would be about 1,100 ft. and the available capacity about 30,000 hp.

The voltage of the main transmission system is to be 110,000, but sections may be altered later to 135,000 if required. Secondary transmission lines will operate at 66,000 volts, while the voltage of the high-tension distribution lines will be 11,000.

A New Ice Building Design

At the Jan. 25th meeting of the New York Section of The American Society of Refrigerating Engineers, held Wednesday evening, Charles Neeson, of the Electric Bond & Share Company, presented a paper on "New Type of Ice Plant Building Design."

The design embraced a combination of new features relative to a standardized type of refrigerating plant that has worked out very well in the South, by means of which a great deal of engineering work could be saved and economies effected by its use.

It was stated that it was quite an advantage to use cinders as an insulating surface for the floor instead of cork or other types of insulating elements. This cinder foundation covered with concrete makes an excellent flooring and is a permanent foundation.

A rather new departure from the usual present practice was the placing of the brine tank directly over the freezing room without any insulation at the bottom of the tank. The freezing room and the side of the tank are insulated by cork put on the outside of the building, and then this cork insulation is surrounded by hollow tile or brick facing.

An additional feature of this type of construction is its flexibility for future growth, and equipment can be added to the plant with a comparatively small increase in cost.

Dean Schneider Pictures the Future

At the request of John O. Sage, president of the Union Central Company, Dean Herman Schneider of the College of Engineering and Commerce of the University of Cincinnati, prepared a prophecy of future scientific knowledge. This was read at the dedication ceremony of the company's annex, Jan. 16, 1928, by Clyde W. Park, professor of English, College of Engineering and Commerce, and then placed in the cornerstone of the new building.

This attempt to unveil the future is the work of an outstanding engineer whose position, associations and manifold interests enable him to survey broadly, but keenly, the world picture of today and to see the implications of the forces now at work in the fields of pure and applied science and of social relaitons. An abstract of some of his predictions is given in the following:

At the present time scientific research has brought matter down to the electron and the proton, and has given us the probable structure of the atom and the molecule. The dissociation of molecules and the killing of bacteria at critical electro-magnetic wave lengths are accomplished. The nature of gravitation is not known, but with knowledge now in hand, it should be known within two decades. The activation of compounds by the application of electromagnetic waves of appropriate length is established.

Turning to the future, it is safe to forecast that diseases due to bacteria will be cured as soon as they develop, by killing the bacteria with electromagnetic waves of definite lengths, the waves being developed where the bacteria have their lodgment. This will probably be by what we now call secondary radiation; that is, by introducing a high atomic non-toxic substance which fluoresces at the critical wave and which is selectively absorbed by the bacteria, and then hitting the substance with X-rays. This can now be done in test tubes.

Knowledge of the nature of gravitation may make possible the development of new types of airships not depending on air pressure. In time a simple, safe, compact machine will be developed. People will be able to go long distances quickly. However, the need for long-distance traveling may be reduced by the development of selective visual and audible communication systems. These may result in decentralization of population.

As to the source and the nature of your mechanical power 100 years hence, the scientific thought of today runs toward the huge stores of energy locked up within the atom and predicts their release at some future time. The safest scientific guess is that you will have it, but as to the mechanisms involved in its use, further speculation would be futile. To assume that you will have it, and to assume further that you will know the art of molecular synthesis, leads a 1928 mind into mazes too intricate to follow.

I should be without any guide post as to the trend of spirtual development in the next 100 years (using the word spiritual in its broadest sense), were it not for the unexpected spiritual by-products of scientific research. My own observations, and a study of what some of the great present-day scientists have written and said, lead me to the belief that during the next 100 years science, religion, philosophy and even enlightened selfishness will walk together with greater surety toward the destiny for which mankind has been groping and blundering down the ages.

Hydraulic Survey Committee Plans Work

C. M. Allen, chairman of the Survey Committee of the Hydraulic Division of the American Society of Mechanical Engineers, announces that the committee is now organized to begin its survey of hydraulic research both in this country and abroad. It is planned to go back only five years in securing information on research begun or completed unless something of special importance was done before that time. Upon completing its survey the committee will recommend to the division projects for research which they consider the most important.

In this work N. R. Gibson is to collect what research work has been done by the power companies exclusive of the Pacific Coast; L. F. Harza was appointed with W. F. Uhl to take care of any research work that the consulting engineers have done or have been connected with; Forrest Nagler and R. V. Terry are to study the work done by the waterwheel manufacturers; R. E. B. Sharp is to handle the European situation; A. I. Winter the power companies in the south, and C. M. Allen is to get information from the hydraulic laboratories of the engineering colleges.

Japan's Largest Turbo-Generator Completed

Japan's largest electric turbo-generator, 20,000 kw., was completed recently at Nagasaki, according to a report from Consul Henry B. Hitchcock, Nagasaki, Japan, made public by the Department of Commerce. It was given a public test at the engineering works in the presence of electrical engineers from other Japanese electrical companies.

The generator was built under licenses from a number of patentees in foreign countries. It is thought in Nagasaki to combine features of the different national types of the United States, Switzerland and England.

It was stated that, so far as practical, use had been made of materials and parts made in Japan in the construction of the new generator.

Power Production in Italy Increases

Virtually the whole of Italy's electrical energy is generated by water power, the steam power station chiefly serving only as reserves to the hydro-electric stations at critical periods in the dry season. In 1913-14 the installed capacity of Italian power stations amounted to 960,000 hp. and the power output for the same period was 2,312,000,000 kw.-hr. An enormous post-war development has taken place since 1920.

The total installed capacity up to the end of 1926 was 3,630,000 hp., in the ratio of 79 per cent for hydro-electric and 21 per cent for steam-power stations. Of the total capacity of 2,824,000 hp. for hydro-electric stations, 1,677,000 hp. is installed in the basin of the River Po. It is worthy of note that, despite the increasing utilization of water power, the installed capacity of steam power and Diesel engine stations is on the increase. The average power consumption per capita rose from 70 kw.-hr. in 1914 to 185 in 1925. By far the greater part of this consumption of electric energy generally goes to supply the demands of industry.

Notwithstanding the development of Italy's water power, the consumption of coal shows no sign of decreasing. The consumption amounted to 12,145,-557 tons in 1925, in comparison with 11,343,085 tons in 1913, and the fact that only a small proportion is used in the steam-power generating stations, 196,481 tons in 1926, is striking evidence of the constantly increasing industrialization of Italy.

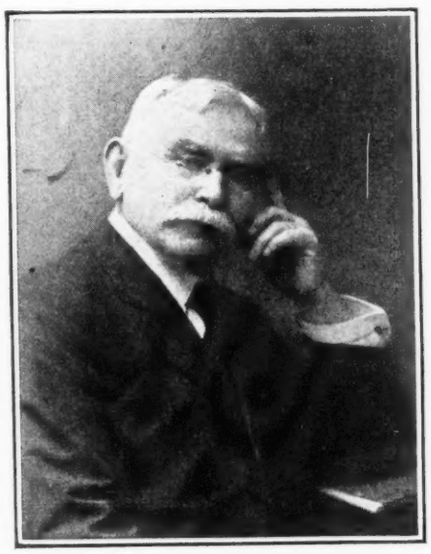
According to Consul General T. Jaeckel, Milan, the process of obtaining benzine, the so-called synthetic gasoline, by distillation from coal, which had already been studied in Germany, has been carried out on a laboratory scale in Italy, by Ingeniere Commendatore Bianchi and Ingeniere Guardabassi. The engineers mentioned have experimented successfully at Rho with distillation from lignites at low temperatures. They have accomplished the cracking of the coal tar by means of a catalytic process at ordinary pressure which is said to be an entirely new one. The results of the tests, which have been on a semi-industrial scale, especially those made with lignites carrying pitch, have proved satisfactory, and it has been decided to construct a demonstrating plant. It is expected that the process will have an important effect in solving the Italian fuel problem, especially if it is also applied to bituminous material, owing to the fact that its use near the lignite mines will make it possible to obtain not only synthetic gasoline and lubricating oils, but also readily transportable anhydrous coke of high caloric content, said to be superior to the best British coal.

D. Kennedy, a Pioneer in Valve Manufacturing, Dies at Age of 80

Daniel Kennedy, president of the Kennedy Valve Manufacturing Company, died at Hot Springs, Arkansas, on Jan. 14, after a short illness. At the time of his death Mr. Kennedy was in his eightieth year.

Coming to America from Ireland as a youth of seventeen, he became a self-made man in every sense of the word. His first business venture was in connection with the old Boston Dry Dock, built in the Erie Basin, Brooklyn, N. Y., in 1877, and now owned by Robbins Dry Dock & Repair Co.

The valve equipment for controlling the flow of water in and out of this



Daniel Kennedy

dock was an important factor in its operations. In competition with designs submitted by valve builders of that period, those of Mr. Kennedy were chosen, and he was awarded the contract for building the gate valves in sizes ranging from 48-in. down. This contract established the firm of Daniel Kennedy, which was later incorporated and the name changed to the Kennedy Valve Manufacturing Company.

Mr. Kennedy's primary interests were in his family and in his business, to both of which he was conscientiously devoted. In private life he was of a retiring disposition and had an abundance of sterling qualities. His philanthropies were innumerable, but were carried out anonymously and with the reserve that was characteristic of the man. With his hundreds of employees he enjoyed that popularity which is invariably courted by men in his position, but is often lacking. He knew many of his men personally, called them by their first names, and lived to see many of the sons and even grandsons of old-time employees grow up in the business.

Besides his widow, Mr. Kennedy is survived by three sons, Matthew E., J. C. and Clarence H., treasurer and general manager, works manager and general sales manager, respectively, of the Kennedy Valve Manufacturing Co., and by three daughters.

Obituary

W. S. HAGGAS, a well-known mechanical engineer of Toronto, Ont., died on Jan. 24 in his 59th year. He designed and constructed the first internal-combustion engine that was built in Canada and was connected with several British engineering concerns. In 1922 he was made chief Canadian representative for the Keighley Gas & Oil Company, of England. Two years later he started in business for himself with his son, William T. Haggas, in Toronto, under the name of Haggas-Keighley Oil Engine Company. Mr. Haggas is survived by his widow, two sons and three daughters.

WILLIAM D. KLIPFEL, who until recently was head of the Klipfel Manufacturing Company, Chicago, Ill., died of heart disease at his home in that city on Jan. 22. On account of ill health he had retired recently from active work in the firm which he founded. He was 72 years old and spent his life in Chicago, identified with the manufacture of valve equipment. He was the inventor of many of the products manufactured by his company, which include boiler regulation, reducing valves, float valves, etc.

Personal Mention

H. M. COOK, formerly engineer of tests of the Brooklyn Edison Company, has been appointed assistant to director of personnel and statistics. E. C. M. Stahl, who was assistant superintendent at the Hudson Avenue generating station, succeeds Mr. Cook as engineer of tests.

OLIVER A. CHURCH has been made manager of the Batavia district of the Niagara, Lockport & Ontario Power Company. He has recently been engineer and construction superintendent at Batavia and has been connected with Batavia light and power companies since 1923.

J. V. GONGWER, who was structural engineer on the first unit in the Cushman hydro-electric project for the City of Tacoma, Wash., has been appointed chief assistant engineer of the second unit of this project by Ira S. Davisson, commissioner, Department of Public Utilities. Mr. Gongwer is the first member of the new organization staff and will occupy the position of superintendent of hydraulic design and construction.

Business Notes

THE DAMPNEY COMPANY OF AMERICA, Hyde Park, Boston, announces that the new address of its Connecticut representative is 151 Union Ave., New Haven, Conn.

THE ARMSTRONG MANUFACTURING COMPANY, Bridgeport, Conn., announces the appointment of Edwin J. Dennis as its sales representative in Ohio, Indiana, Michigan and western Pennsylvania.

THE WESTERN NEW YORK UTILITIES COMPANY, which has been supplying gas and electricity to Albion, N. Y., and other towns, has become part of the Niagara, Lockport & Ontario Power Company and will hereafter be known by that name.

THE CLIMAX ENGINEERING COMPANY, of Clinton, Iowa, announces the appointment of the Equitable Equipment Company, 410 Camp St., New Orleans, Louisiana, as a Climax Sales and Service representative for the territory of lower Louisiana and Mississippi.

CONSOER, OLDER & QUINLAN, consulting engineers, Chicago, announce that on Jan. 23 George B. Mulloy joined the organization to take charge of a new department of industrial engineering. Mr. Mulloy has been employed by Armour & Company for twenty years and during the last few years has filled the post of assistant superintendent of motive power and chief combustion engineer.

THE LINCOLN ELECTRIC COMPANY, of Cleveland, Ohio, announces the retention of A. M. MacFarland as a general sales and development engineer. He will devote his efforts to the development and special application of automatic carbon arc welding, with headquarters at Cleveland. During the last seven years Mr. MacFarland has contributed some thirty patents to the development of the welding industry. His wide knowledge of the design and practical requirements of automatic arc welding equipment renders him well fitted for the new work he is now undertaking.

THE BAILEY METER COMPANY, Cleveland, Ohio, announces the appointment of M. Greenberg as acting manager of its Pittsburgh Office, at 402 Oliver Building. Mr. Greenberg, formerly manager of the company's St. Paul office, will have charge of the sales and service work for the Bailey Meter Company in the Pittsburgh territory. E. Brosius, formerly manager of the Pittsburgh Office, sailed for Durban, South Africa, on Jan. 28 to take charge of the installation and adjustment of Bailey Automatic Combustion-Control Equipment recently shipped to that point for a new pulverized coal fired boiler plant.

Trade Catalogs

PULVERIZED COAL BURNER — The Riley Stoker Corporation, Worcester, Mass., is prepared to send to those requesting it a new circular which describes the new Riley flare-type burner used in conjunction with pulverized-coal installations. An attractive feature of this bulletin is the frontispiece, which shows in color the combustion of pulverized coal issuing through the openings of the burner

DRAFT GAGES—A new pointer draft gage is described in Bulletin 10, issued by the Ellison Draft Gage Company, Chicago, Ill. This gage is of the gasometer type and is made in single- and multi-pointer units, for both panel and wall mounting. One feature of these new machines is that they are arranged so that pressure cannot blow through under the bell of the gasometer when the fireman is using the soot-blowing apparatus on the boiler.

POWER FOR IRRIGATION — The Westinghouse Electric & Manufacturing Company has issued a special bulletin No. 1786, devoted to the subject of "The Modern Power for Irrigation." This pamphlet is not addressed distinctly to the power-plant engineer, but is assumed to carry a more special appeal to the farmers who make use of irrigation. Various types of vertical motors arranged for direct connection to propeller-type pumps are shown.

NEW PIPE-FLANGE STANDARDS—It is a matter of general knowledge that a number of the engineering societies have been devoting considerable study to the question of pipe-flange dimensions for high steam pressures. The American Engineering Standards Committee has developed a set of standards for various pressures, and the National Valve & Manufacturing Company, Pittsburgh, Pa., has embodied these various tables of dimensions in a new pamphlet which they have just issued. In view of the probable general acceptance of the Standards Committee's recommendations, this book should be welcome to users and designers of power-plant equipment.

STOKERS FOR OFFICE BUILDING—In the past the power plant of the average office building, apartment house, hotel and school, was noted for its lack of modernness. Hand firing was almost universally followed, and it has only been recently that the advantages of automatic stoker firing have been accepted widely by designers of such buildings. Architects and building engineers will find the catalog just issued by the Riley Stoker Corporation, on "Combustion Equipment for the Office Building, Apartment House, Hotel and School," of interest. It is illustrated by numerous photographs of such stoker plants, together with illustrations of the several stokers manufactured by this corporation.

HIGH-PRESSURE VALVES—That high pressure has definitely taken its place in power-plant practice is evidenced by the fact that the Edwards Valve & Manufacturing Company, East Chicago, Ind., has brought out a complete catalog of 143 pages devoted almost exclusively to valves and fittings for pressures of 300 lb. and above. Valve dimensions are given for valves of all the standard pressures up to 1,350 lb. per sq.in. There is, in addition, a complete discussion of the requirements in the way of materials necessary in the construction of high-pressure fittings.

Coming Conventions

American Boiler Manufacturers Association, winter meeting, Hotel Cleveland, Cleveland, Feb. 7; A. C. Baker, sec., 801 Rockefeller Bldg.

American Institute of Electrical Engineers, winter convention at New York City, Feb. 13-17, F. Hutchinson, secretary, 29 West 39th St., New York City; St. Louis Regional Meeting, District No. 7, March 7-9; Baltimore Regional Meeting, District No. 2, April 17-19; New Haven Regional Meeting, Northeastern District, No. 1, in May; Summer Convention, in Denver, June 25-29.

American Institute of Refrigeration, Washington, D. C., May 10-11.

American Society of Heating & Ventilating Engineers, hold general meeting at Hotel Pennsylvania in New York City, Jan. 23-26; A. V. Hutchinson, sec., 29 W. 39th St., New York.

American Society of Mechanical Engineers, spring meeting in Pittsburgh, May 14-17; Calvin Rice, secretary, 29 West 39th St., New York City.

American Society for Testing Materials, Atlantic City, June 25-29.

American Water Works Association. Annual meeting, Hotel Fairmont, San Francisco, June 11-16; W. M. Niesley, 170 Broadway, New York City.

Association of Iron and Steel Electrical Engineers, annual convention at Hotel Stevens, Chicago, June 25-29.

Chicago Power Show to be held at the Coliseum, Feb. 14-18. G. E. Pfisterer, manager, 53 W. Jackson Blvd., Chicago.

Midwest Power Conference to be held at the Hotel Stevens, Feb. 14-17; G. E. Pfisterer, secretary, 53 W. Jackson Blvd., Chicago.

National Association of Stationary Engineers, annual convention at Detroit, Sept. 11; Fred Raven, 417 South Dearborn St., Chicago.

National Board of Boiler and Pressure Vessel Inspectors, meeting at Erie, Pa., June 18-20.

National Electric Light Association, Convention and exhibition, Atlantic City, N. J., June 4-8; A. Jackson Marshall, secretary, 420 Lexington Ave., New York City.

National District Heating Association, annual meeting at Ambassador Hotel, Atlantic City, June 12-15; D. J. Gaskill, sec., 112 West 4th St., Greenville, Ohio.

The National Marine Engineers' Beneficial Association, 53rd annual convention, will meet at the Lee House, 15th and L Streets, N. W., Washington, D. C., February 13-18. Albert L. Jones, Secretary-Treasurer, 313 Machinists Building, Washington, D. C.

Stoker Manufacturers Association, fall meeting at Greenbrier Hotel, White Sulphur Springs, W. Va., Oct. 22-24.

Universal Craftsmen Council of Engineers, Newark, N. J., Aug. 7-10.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	Market Quoting	Jan. 26, 1928
Navy Standard	New York	$2.25@$2.50
Kanawha	Hampton Roads	1.63@ 1.98
Smokeless	Cincinnati	2.25@ 2.50
Smokeless	Chicago	2.25@ 2.50
S. E. Kentucky	Chicago	1.40@ 1.60
Steam	Pittsburgh	1.40@ 1.65
Gas Slack	Pittsburgh	1.15@ 1.35
Big Seam	Birmingham	2.00@ 2.25
Anthracite (Gross Tons)		
Buckwheat	New York	$3.00@$3.35
Birdseye	New York	1.60@ 1.85

FUEL OIL

New York—Feb. 2, light oil tank-car lots, 28@34 deg. Baumé, 5c. per gal.; 36@40 deg., 6c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Jan. 24, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.55 per bbl.; 26@28 deg., $1.60 per bbl.; 28@30 deg., $1.65 per bbl.; 30@32 deg., $1.70 per bbl.; 32@36 deg., gas oil, 4.276c. per gal.; 38@40 deg., 5.23c. per gal.

Pittsburg—Jan. 12, f.o.b. local refinery, 30@34 deg., fuel oil, 4½c. per gal.; 36@40 deg., 4¾c. per gal.

Philadelphia—Feb. 1, 26@30 deg., $2.00@$2.06 per bbl.; 13@19 deg., $1.26 @$1.32 per bbl.; 22 plus, $1.58@$1.64 per bbl.; 27@30 deg., $2.10@$2.16 per bbl.

Cincinnati—Jan. 31, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 4.9c. per gal.; 26@30 deg., 5.15c. per gal.; 30@32 deg., 5½c. per gal.

Chicago—Jan. 28, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl.; 22@26 deg., 80@85c. per bbl.; 26@30 deg., 90c. per bbl.; 30@32 deg., $1.05@$1.10 per bbl.

Boston—Jan. 30, tank-car lots, f.o.b. 12@14 deg. Baumé, 4½c. per gal.; 28@ 32 deg., 5.8c. per gal.

Dallas—Jan. 28, f.o.b. local refinery, 26@30 deg., $1.45 per bbl.

NEW PLANT CONSTRUCTION

Ark., El Dorado—The Arkansas Light & Power Co., Pieron St., Little Rock, plans to expend $1,000,000 during 1928 for additional high voltage transmission lines in Arkansas.

Calif., Culver City—Metro-Goldwyn-Mayer Studios, is having plans prepared for the construction of a boiler house, etc. J. M. Haenke, Subway Terminal Bldg., Los Angeles, is architect.

Calif., Fresno—Fresno-Madera Ice Co., 7th St. and Ventura Ave., plans the construction of an ice cream plant on Blackstone Ave. Estimated cost including equipment $100,000.

Calif., Glendale—Bd. of Education, will receive bids until Feb. 23 for the construction of group of high school buildings including central heating plant, etc. Estimated cost $1,200,000. A. F. Priest, 719 Fay Bldg., Los Angeles, is architect.

Calif., Long Beach—Bowering Soap Co., plans the construction of a factory including power house, etc. Estimated cost $500,000. C. P. Hubert, 210 West 68th St., is architect.

Calif., Los Angeles—J. Morehouse, 692 South Berendo St., is receiving bids for the construction of a 13 story hotel including steam heating system, elevators, etc. at Seventh and Berendo Sts. Estimated cost $650,000. R. M. Bates, 660 South Vermont Ave., is architect.

Calif., Oakland—J. F. McGushen, et al, Central Bank Bldg., plans the construction of a hotel at Holy Name College site. Estimated cost $3,000,000. Architect not selected.

Conn., Bridgeport—Southern New England Telephone Co., I. R. Harney, Exchange Mgr., is having preliminary sketches made for an exchange building on Courtland St. Estimated cost $3,000,000. R. W. Foote, 185 Church St., is architect.

Conn., Hartford—Horace Bushnell Memorial Hall Corp., C. F. T. Seaverns, Pres., 1265 Asylum St., had plans prepared for the construction of an auditorium at Trinity St. and Capitol Ave. Estimated cost $1,500,000. Helmle, Corbett & Harrison, 130 West 42nd St., New York, N. Y., are architects.

Del., Wilmington—Dravo Contracting Co., Dravo Bldg., Pittsburgh, Pa., plans the construction of a ship building and steel assembling plant on Christina River here.

D. C., Washington—Columbia Medical Building, 1801 Eye St. N. W., awarded contract for an office building at 1821-1829 Eye St. and 911 19th St. N. W. to Lee Paschall, American National Bank Bldg., Richmond, Va. Estimated cost $750,000.

Georgia—Crisp County Power Comn., J. J. Williams, Chn., Cordele, plans a hydroelectric development on Flint River at Warwick, ultimate development 15,000 hp. Plans include power house, 40 x 150 ft., dam maximum head 30 ft.; duplicate power units will be installed to operate on both 30 and 20 ft. heads; present installation includes two units of 30 and 20 ft. heads respectively, ultimate plans contemplate the installation of four 3,600 kw. each. All units will be of vertical shaft type. E. S. Killibrew, Albany, is engineer. J. E. Sirrine & Co., 309 South Main St., Greenville, S. C., are consulting engineers.

Ill., Chicago—Wm. Bernhard & Co., 820 Tower Court, Archts., will receive bids about Feb. 15th for an 18 story apartment building including central refrigeration plant, elevators, etc. at 14 West Elm St. for Elm St. Building Corp., c/o architects. Estimated cost $1,500,000.

Ill., Chicago—S. A. Clifford & Co., 111 West Washington St., is having plans prepared for a 9 story apartment building at 601-605 Deming Pl. Estimated cost $625,000. Keonigsberg & Weisfeld, 155 North Clark St., are architects.

Ill., Chicago—McNally & Quinn, 6 South La Salle St., Archts., will receive bids about Feb. 5 for a 12 story apartment building at 67-75 East Elm St. for Syndicate, c/o Equitable Bond & Mortgage Co., 180 West Washington St. Estimated cost $1,000,000.

Ill., Chicago—One Thousand Twenty Lawrence Ave. Building Corp., c/o Huszagh & Hill, 6 North Michigan Ave., Archts., awarded general contract for a 12 story apartment and stores building to Trimmer-Nydele Co., 111 West Washington St. Estimated cost $1,000,000.

Ill., Chicago—Sanitary Dist. of Chicago, Room 600, 910 South Michigan Ave., will soon award contract for the construction of an electric sub-station on Howard St. for North Side Sewage Treatment Works.

Ill., Chicago—South Central Realty & Development Co., F. J. O'Brien, V. Pres., had plans prepared for the construction of a produce market including hot water heating system at State St. and Indiana Ave. Estimated total cost $5,000,000. W. L. Hoffman, 718 West 63rd St., is architect. Contracts for first 16 units consisting of loading platform will soon be awarded.

Ill., Chicago—Syndicate, c/o F. Brons, 605 North Michigan Ave., awarded contract for the construction of a 16 story apartment building at 1220 North State St. to B. W. Construction Co., 720 Cass St. Estimated cost $1,300,000.

Ill., Dunning—Division of Architects and Engineers, Capitol Bldg., Springfield, will soon award contract for replacing soot blowers at power house of Chicago State Hospital here. W. J. Lindstrom, is supervising engineer.

Ind., Anderson—A. M. Strauss, 415 Calwayne Bldg., Fort Wayne, will receive bids about March 1 for a 6 story hotel including steam heating system, elevators, etc. at 12th and Meridian Sts. here. Estimated cost $700,000. Owner's name withheld.

Me., Bingham—Central Maine Power Co., Augusta, plans the construction of a hydroelectric power development here. Private plans.

Md., Baltimore—Tower Apartment Co., c/o Smith & May, Calvert Bldg., Archts., will soon award contract for a 15 story apartment building including vapor or vacuum steam heating system, elevators, etc. at 39th and University Sts. Estimated cost $1,250,000.

Massachusetts—Boston, Revere Beach & Lynn, R. R., G. F. Wells, Pres., c/o Hempill & Wells, 43 Cedar St., New York, N. Y., Engrs., plans electrification of both the 12 mi. double-track main line between Lynn and East Boston ferry terminal and the Winthrop loop line to include new car equipment, remodeling all stations, installing overhead system and constructing substations, etc. Estimated cost $1,000,000.

Mass., Boston—Boston Lying-In Hospital, L. Balchelder, Chn. Building Com., 431 Massachusetts Ave., is having plans prepared for a 5 story addition to hotel. Estimated cost $1,000,000. Coolidge, Shepley, Bulfinch & Abbott, Ames Bldg., are architects.

Mass., Brockton—Brockton Gas Light Co., 54 Main St., will soon award contract for a 40 x 45 ft. boiler house on Grove St. Estimated cost $125,000. C. H. Tenney & Co., 38 Chauncy St., Boston, are architects and engineers.

Mich., Detroit—Little Sisters of the Poor, F. J. Fisher, General Motors Bldg. is having plans prepared for the construction of an orphans home, including steam heating system, boilers, etc. at Six Mile and Southfield Rds. Estimated cost $700,000. Architect not announced.

Mich., Detroit—Sears Roebuck & Co., Arthington and Homan Sts., Chicago, Ill., plans the construction of a store and warehouse, including steam heating system, boilers, elevators, etc. on Gratiot Ave. Estimated cost $600,000. G. C. Nimmons & Co., 122 South Michigan Blvd., Chicago, Ill., are architects.

Mich., Lansing—Capitol National Bank, is having plans prepared for a 16 story bank and office building including steam heating system, boilers, elevators, etc. on Capitol St. Weary & Alford, 1923 Calumet Ave., Chicago, Ill., Archts.

Mich., Monroe—Consolidated Paper Co., awarded contract for a 4 story, paper factory including steam heating system, boilers, elevators, etc. to Owen-Amos-Kimball Co., 38 Pearl St., Grand Rapids. Estimated cost $400,000.

Minn., Rochester—City voted $200,000 bonds for the construction of heating plant for high and central schools.

Miss., Hernando—City will soon award contract for waterworks improvements including reservoir, 220 g.p.m. centrifugal pump direct connected to a 15 hp., 3 ph., 200 v. motor, etc. S. W. Eason, is engineer.

Mo., Kansas City—Snyder Building Co., 618 Commerce Bldg., will build a 9 story apartment building. Phillips Drotts, 423 Reliance Bldg., is architect. Work will be done by separate contracts.

Mo., Kansas City—Southwestern Bell Telephone Co., Telephone Bldg., awarded contract for a 14 story addition to office building to Swanson Construction Co., Shubert Bldg. Estimated cost $1,750,000.

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Mo., St. Louis—Bd. of Public Service, L. Day, Comr., City Hall, will receive bids until Feb. 28 for addition to waterworks pumping station at City Sanitarium, Arsenal St. and Brannon Ave. Estimated cost $148,000.

Mo., St. Louis—Independent Plumbing & Heating Supply Co., 1119 Chestnut St., will build a terminal and warehouse, loading platform, track, etc., at 3340 Market St. Estimated cost $125,000. Work will be done by separate contract under the supervision of D. R. Harrison, 1106 Ambassador Bldg., Archt.

Mo., St. Louis—J. C. Penney Co. Inc., 330 West 34th St., New York, N. Y., awarded contract for a 12 story warehouse at 14th and Poplar Sts. to Starrett Bros. Inc., 101 Park Ave., New York, N. Y. Estimated cost $1,500,000.

Neb., Omaha—Nebraska Power Co., 17th and Harvey Sts., plans to expend $1,000,000 during 1928 for extensions and improvements to include construction of substations, 60,000 v. transmission line from Omaha to Louisville and Valley, etc.

N. J., Bound Brook—Elizabeth Water Co. Consolidated, 64 Broad St., plans the construction of a filtration plant and pumping station. Estimated cost $40,000. Architect not selected.

N. J., Newark—Roman Realty Co., First National Bank Bldg., Paterson, is having plans prepared for a 10 story apartment including steam heating and refrigeration system, boilers, elevators, etc. on Johnson Ave. Estimated cost $600,000. H. F. Clark, 38 Clinton St., Newark, is architect.

N. J., Verona—Bd. of Chosen Freeholders, will receive bids about Mar. 15 for the construction of Essex Mt. Sanitarium including steam heating, ventilation and refrigeration systems, boilers, elevators, etc. Estimated cost $1,000,000. Sutton, Sutton & Calkins, 402 Broad St., Newark, are architects.

N. Y., Binghamton—Dept. of Mental Hygiene, Capitol, Albany, will soon award contract for the construction of a cold storage plant at Binghamton State Hospital here.

N. Y. Freeport—Freeport Hospital, c/o D. W. Pine, 25 South Main St., is having plans prepared for a hospital at Prince and Pennsylvania Aves. Estimated cost $500,000. Purdy & Davis, 350 Madison Ave., are architects. Kidner & Rosenfeld, 155 East 42nd St., are consulting architects.

N. Y., New York—B. P. Gerussi, 655 East Fordham Rd., had plans prepared for a 6 story apartment building at 341 Hillside Ave. Estimated cost $1,000,000. A. E. Kluppelberg, 375 East Fordham Rd., is architect.

N. Y., New York—Herald Tribune, 225 West 40th St., plans the construction of a 20 story loft and printing plant. Estimated cost $1,000,000.

N. Y., New York—Master Builders, Inc., L. L. Hersh, Pres., 310 Riverside Dr., had plans prepared for a 24 story hotel at Riverside Dr., and 103rd St. Estimated cost $1,750,000. Helmle, Corbett & Harrison, 130 West 42nd St., are architects.

N. Y., New York—Sixty Gramercy Park North, Inc., J. R. Barr, Pres., 347 Madison Ave., had plans prepared for a 15 story apartment building at 105 East 31st St. Estimated cost $800,000. E. Roth, 1440 Broadway, is architect.

N. C., Raleigh—Consolidated Engineering Co., 20 East Franklin St., Baltimore, Md., plans the construction of an 8 story hotel at Hargett and Dawson Sts. here. Estimated cost $800,000.

N. D., Fargo—Great Northern Railway Co., St. Paul, Minn., plans improvements to railroad yards and terminal including new power plant, addition to roundhouse, etc. here. Estimated cost $250,000. J. R. Davis, is chief engineer.

O., Canton—W. P. English, 116 Cleveland Ave., N. W., plans the construction of an office and stores building at Market Ave. and 5th St. Estimated cost $750,000.

O., Youngstown—Youngstown Hospital Assn., plans the construction of a hospital, nurses home, etc. Estimated cost $1,500,000.

Okla., Vici—E. W. Baker & Co., Medical Arts Bldg., Oklahoma City, is having preliminary plans prepared for the construction of a 10 ton raw water ice plant. Estimated cost $30,000. Private plans.

Okla., Tulsa—A. C. Johnson, National Bank Commerce Bldg., plans the construction of a 16 story hotel at 7th and Main Sts. A. C. Wiser, 1319 R. A. Long Bldg., Kansas City, Mo., is architect.

Ore., Eugene—State Board of Control, Salem, is having plans prepared for the construction of a dormitory here. Estimated cost $2,000,000. Bennes & Herzog, Chamber of Commerce Bldg., Portland, are architects.

Pa., Philadelphia—Dept. of City Property, plans the construction of a convention hall at 34th and Pine Sts. Estimated cost $2,500,000. W. S. Covell, 1315 Walnut St., Acting City architect.

Pa., Philadelphia—L. E. Jallade, 15 East 47th St., New York, N. Y., Archt., will receive bids until Feb. 10 for a 26 story annex here at 15th and Arch Sts., for Y. M. C. A. Estimated cost $1,200,000.

Pa., Philadelphia—Peyton Realty Co., c/o Integrity Trust Co., 717 Chestnut St., plans the construction of a 21 story bank and office building at 16th and Walnut Sts. Estimated cost $2,250,000. S. M. Green, 496 Bridge St. and A. H. Lavalle, Springfield, Mass., are architects.

Pa., Pittsburgh—National Biscuit Co., 6145 Penn Ave., will soon award contract for addition to bakery at Penn Ave. and Lambert St. Estimated cost $400,000. L. J. Wirsching, Jr., 85 9th Ave., New York, N. Y., is architect.

R. I., Cranston—City Lease & Building Co., c/o G. B. Long, 470 Atlantic Ave., Boston, Mass., awarded contract for the construction of a warehouse, bakery and garage here to Long Construction Co., 470 Atlantic Ave., Boston, Mass. Estimated cost $750,000. The Great Atlantic & Pacific Tea Co., Somerville, Mass. is lessee.

R. I., Providence—Providence County Comn., awarded contract for the superstructure of a court house at College, Benefit, Hopkins and South Main Sts. to J. W. Bishop Co., 93 Eddy St. $1,345,364.

S. C., Clarks Hill—Savannah River Electric Power Co., Greenwood, has been granted permit by the Federal Power Comn. to construct a 120,000 hp. hydro-electric plant and dam, 4,200 ft. long on the Savannah River in McCormick County, S. C., and Columbia County, Ga.

Tenn., Knoxville—Knoxville Gas Co., H B. Bonner, Gen. Mgr., c/o H. L. Doherty Co., 60 Wall St., New York, N. Y., plans development to cover 8 year period including construction of a gas plant, also extensions to lines here. Estimated total cost $2,000,000. Engineering Dept. of H. L. Doherty Co., in charge. First unit to cost $500,000 will be built in 1928.

Tex., Amarillo—City is having preliminary plans prepared for waterworks improvements including pumping equipment, etc. Estimated cost $130,000. H. B. Jones, is City engineer.

Tex., Austin—O. O. Norwood, West 7th St., is having plans prepared for a 12 story office building including steam heating and cooling systems, elevators, etc. Estimated cost $500,000. Giesecke & Harris, 207 West 7th St., are architects.

Tex., Dallas—Owner, c/o P. Burrus, American Exchange Bank Bldg., will receive bids until Mar. 15 for the construction of a factory. Estimated cost $900,000. Architect not announced.

Tex., Fort Worth—Montgomery-Ward Co., Chicago Ave. and Larr St., awarded contract for an 8 story jobbing building including steam heating system, elevators, etc. at Camp Bowie Blvd. to Thomas S. Byrne, Van Zandt Bldg. Estimated cost $1,293,000.

Tex., Galveston—American National Insurance Co., c/o Shearn Moody, Pres., will receive bids about Mar. 3 for an 11 story office building. Estimated cost $850,000. A. Fraser, American National Bank Bldg., is architect.

Tex., Galveston—W. L. Moody, Jr. & Associates, will receive bids about Feb. 8 for the construction of an 11 story hotel including elevators, etc. Estimated cost $1,000,000. A. Fraser, American National Insurance Bldg., is architect.

Tex., Odessa—Southern Ice & Utilities Co., will soon receive bids for a 30 ton ice plant. Estimated cost $50,000.

Tex., San Antonio—J. J. Nix, c/o Lanier Hotel, is having plans prepared for a 13 story hotel and garage including circulating ice water system, elevators, etc. at Navarro and College Sts. Estimated cost $1,850,000 H. T. Phelps, c/o Hicks Bldg., is architect.

Va., Ocean View—Ocean View Holding Co., Inc., awarded contract for the construction of a hotel to Miller Engineering Co., Royster Bldg., Norfolk. Estimated cost $700,000.

Wis., Milwaukee—Shorecrest Hotel Co., 343 Summit Ave., awarded contract for an 8 story hotel at Prospect and Lafayette Sts., to S. M. Siesil Co., 160 Ogden Ave.

Ont., Fort Erie—Fort Erie Artificial Ice Co., G. F. Tabor, Mgr., plans the construction of an ice arena including artificial ice plant. Estimated cost $175,000.

Ont., Oshawa—Governors Oshawa General Hospital, C. T. Connat, Simcoe St., Chn., will receive bids until Feb. 11 for the construction of a central heating plant. Estimated cost $30,000.

Ont., Ottawa—Brading Breweries Co., 451 Wellington St., plans the construction of a brewery including refrigeration plant, etc. Noffke, Monn & Sylvester, Central Chambers, are engineers.

Ont., Plantagenet Springs—J. N. Coupal, plans the construction of a hydro-electric plant on Nation River to include dam, power house, turbine, generator and electrical equipment, etc. Engineer not selected.

Equipment Wanted

Combustion Instruments—Liberty Fuel Co., C. P. Crawford, Fuel Engr., 809 Kearns Bldg., Salt Lake City, Utah, plans to purchase portable combustion instruments for checking efficiency of boiler and other furnaces.

Compressor—Shipman Machinery Co., 218 Summer St., Boston, Mass., plans to purchase a 10 x 8 portable compressor.

Engines—Manning Electric Light & Power Co., Manning, Ia., plans the installation of two 400 hp. Diesel engines for proposed generating station. Estimated cost $200,000.

Generator Unit—Robert W. Lake, Lake Engineering Co., 321 Center St., Wheaton, Ill., plans to purchase a turbo-generator unit.

Hoists, Cutting Machinery, etc.—Marble Mountain Co., c/o E. A. Bruder, Pres. and Gen. Mgr., Los Angeles, Calif., plans to purchase and install equipment for marble quarries including hoists, etc., at Paisano, Tex. Estimated cost $75,000.

Ice Plant Equipment—Central Power & Light Co., Frost Bldg., San Antonio, plans the installation of machinery and equipment including ice conveyor, etc., for proposed improvements to ice plant. Estimated cost $100,000.

Ice Plant Equipment—New England Ice Co., 45 Edwards St., Hartford, Conn., is receiving bids for equipment for proposed ice plant. Estimated cost $125,000.

Motors—Buandiere du Nord, 1387 Villevay St., Montreal, Que., plans to purchase four 37 hp. electric motors.

Pump—Whitney & Co., Inc., Leominster, Mass., plans to purchase a 1½ in. centrifugal pump.

Pump and Motor—City of Gotebo, Okla., H. H. Cossell, Clk., will receive bids until Feb. 15 for a triplex pump and motor for proposed waterworks improvements. Estimated cost $24,000.

Pumping Equipment—West Texas Utilities Co., Abilene, Tex., is receiving bids for pumping equipment etc. for proposed waterworks improvements. Estimated cost $300,000.

Pumps, Etc.—Bd. of Public Service, J. Pritchard, Dir., St. Louis, Mo., will receive bids until Feb. 21 for furnishing and installing one house and two boiler feed pumps, etc. in municipal service building.

Pumps and Motors—City of Monrovia, Calif., will readvertise for bids soon for pumps and motors for proposed waterworks improvements. Former bids rejected.

Refrigerator—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Dec. 15 for mortuary refrigerator consisting of automatic refrigerating machine, compressor, motor, automatic control and safety devices, etc. at Naval Hospital, Norfolk, Va.

Refrigeration Equipment—Bureau of Yards & Docks, Navy Dept., Washington, D. C., will receive bids until Feb. 29 for refrigeration equipment including motor driven brine pump, motor, compressor, switchboard, etc. at Marine Barracks, Navy Yard, Mare Island, Calif.

Soot Blowers—Shady Side Academy, J. A. Graham, Supt. of Bldgs., Drawer G, Oakland station, Pittsburgh, Pa., plans to purchase soot blowers.

Turbine Reduction Gear and Generator—Engineers Office, War Dept., Washington, D. C., plans the installation of a steam turbine reduction gear and 750 kw. generator at St. Louis, Mo.